

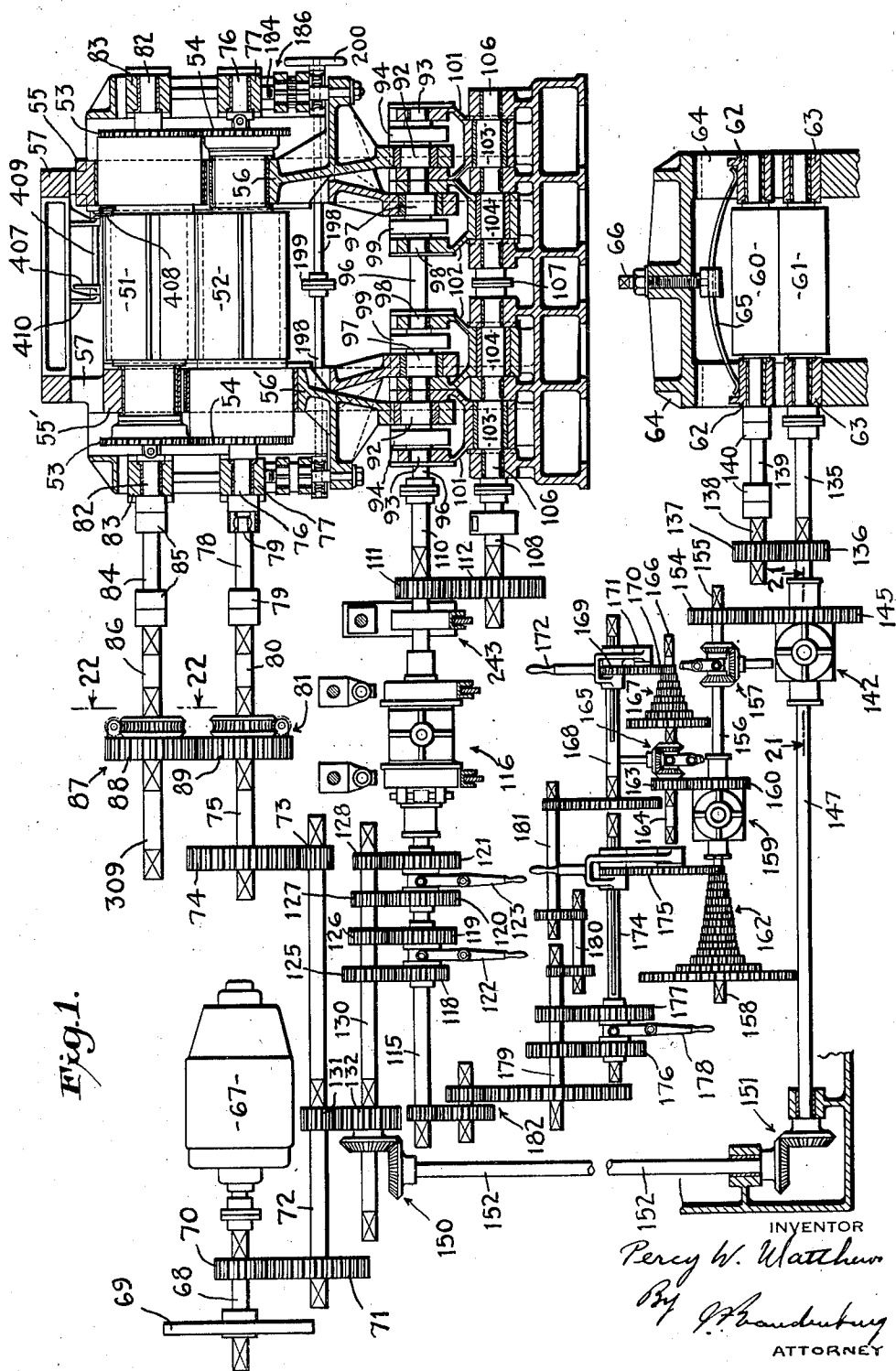
Feb. 9, 1937.

P. W. MATTHEWS

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FLYING SHEAR

Original Filed Feb. 26, 1934 11 Sheets-Sheet 1



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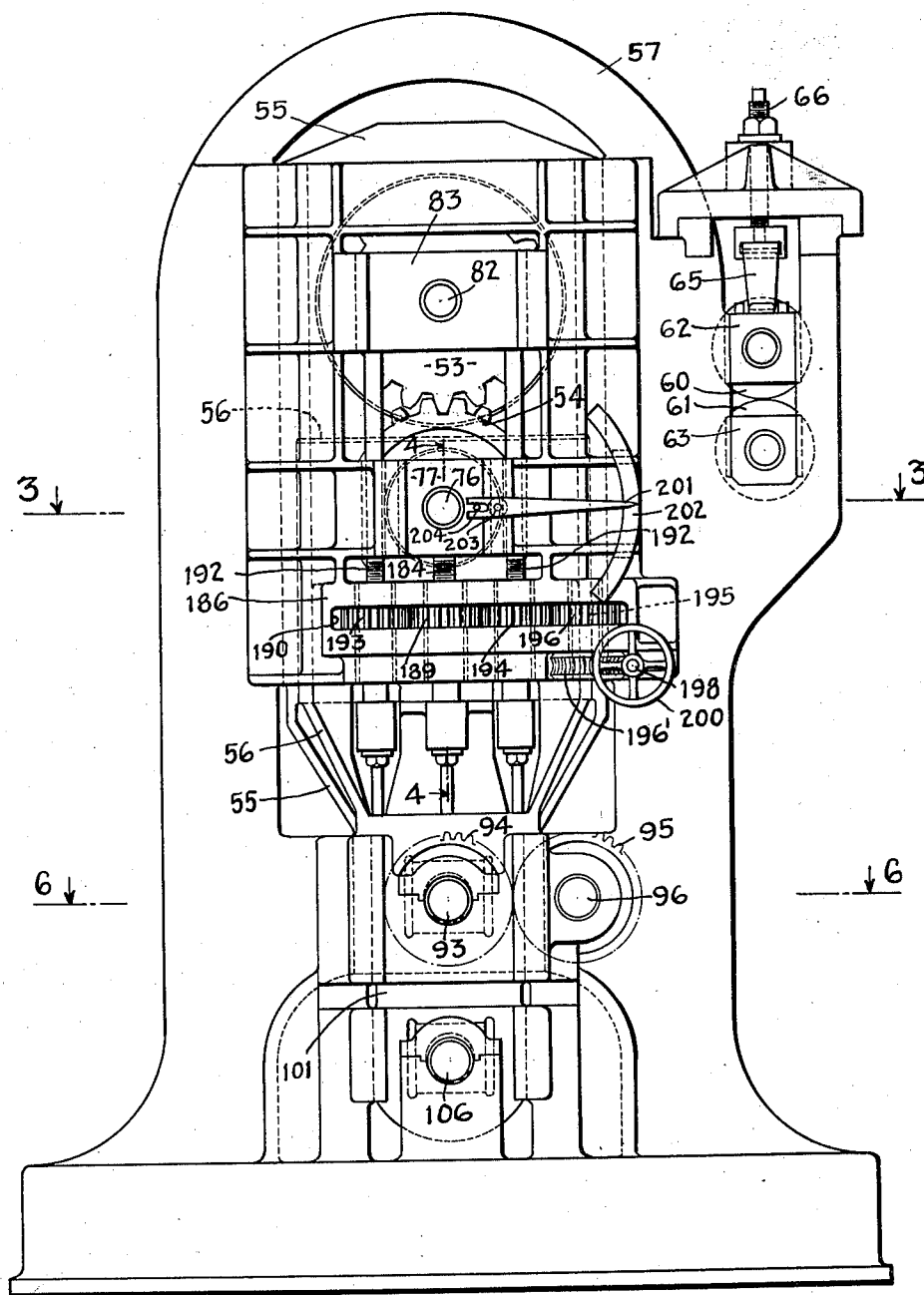
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FLYING SHEAR

Original Filed Feb. 26, 1934

11 Sheets-Sheet 2



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FLYING SHEAR

Original Filed Feb. 26, 1934 11 Sheets-Sheet 3

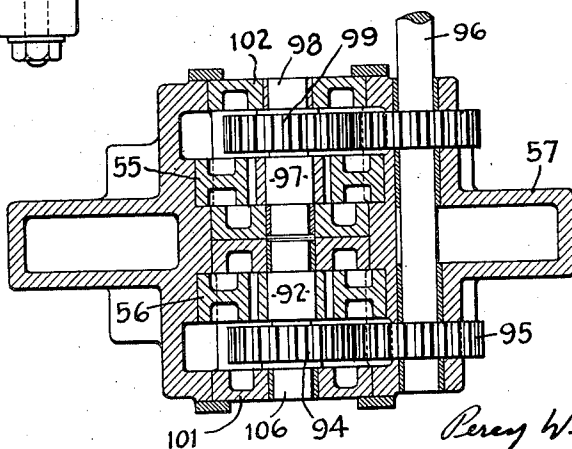
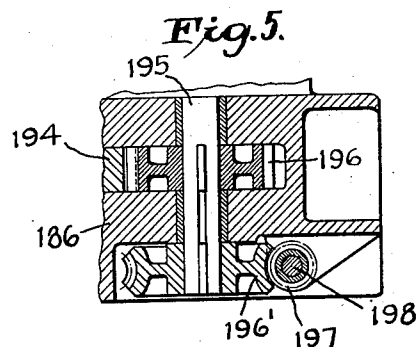
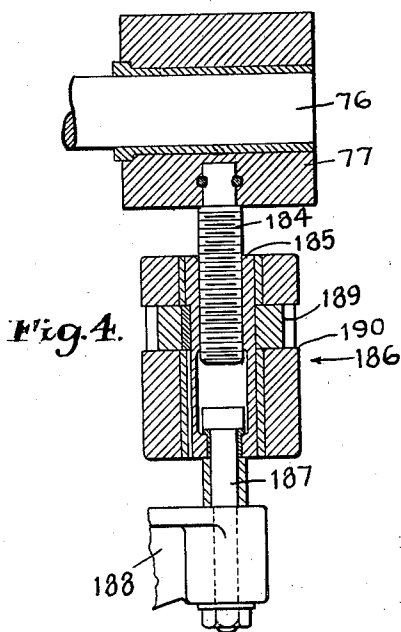
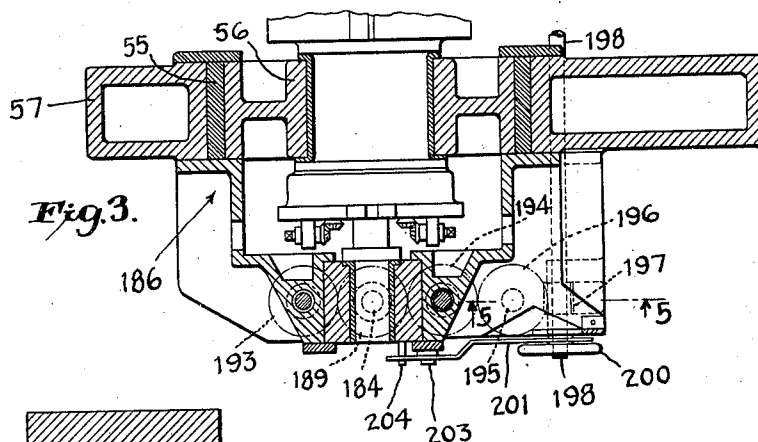


Fig. 6.

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FLYING SHEAR

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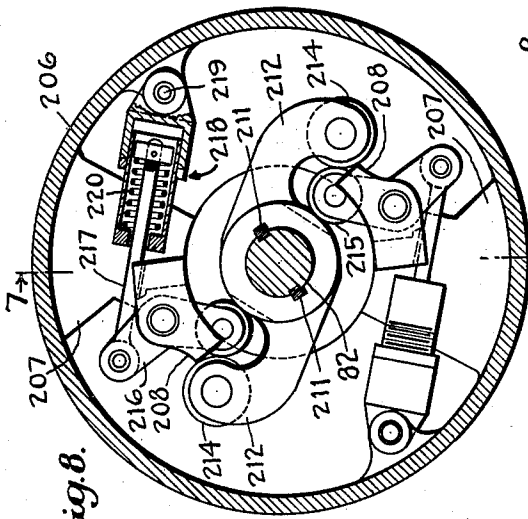


Fig. 8.

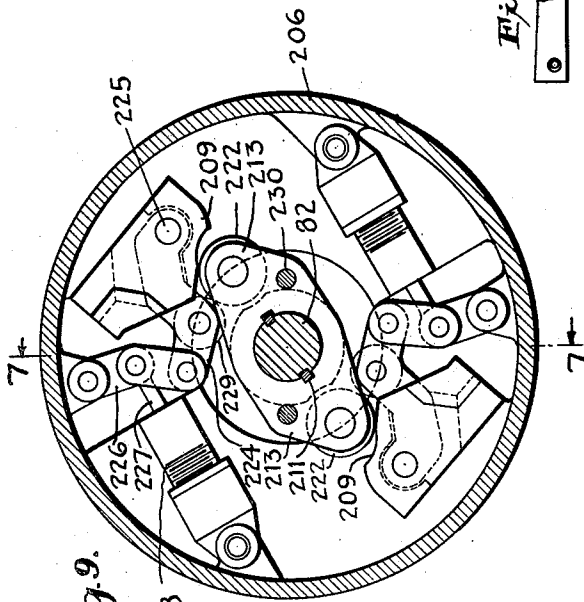
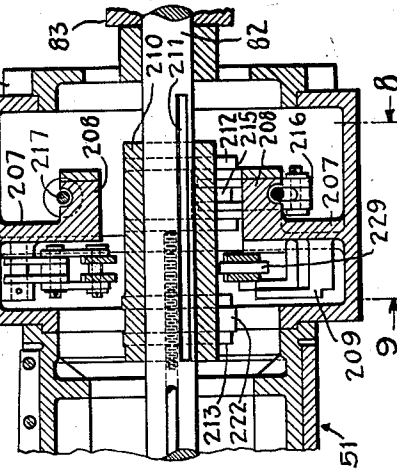


Fig. 9.

Fig. 12.



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11 Sheets-Sheet 5

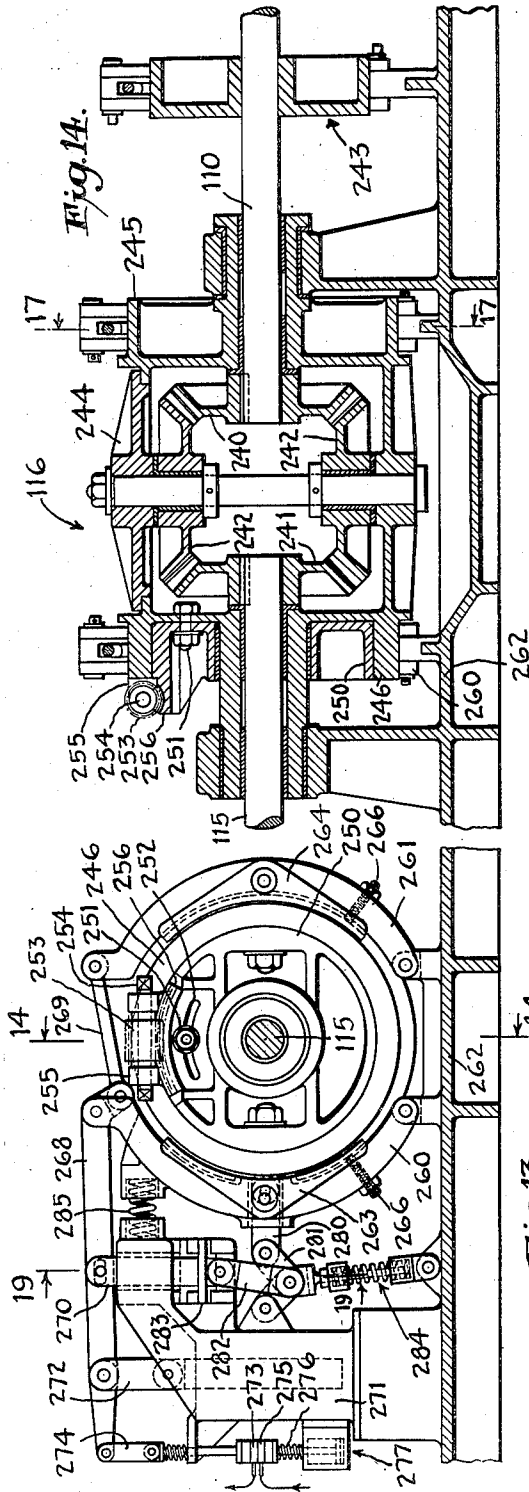


Fig. 13.

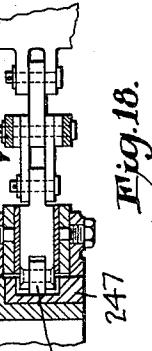


Fig. 18.

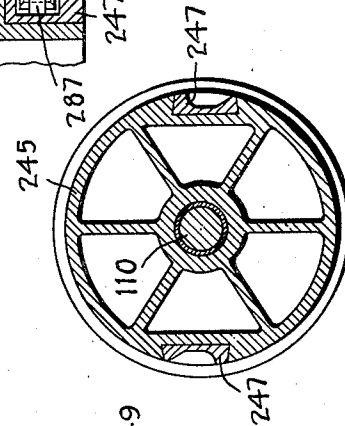


Fig. 17.

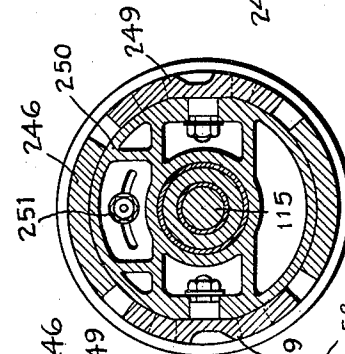


Fig. 16.

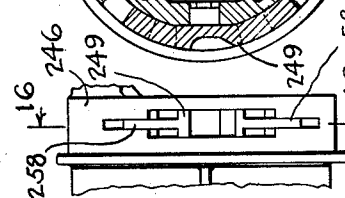


Fig. 15.

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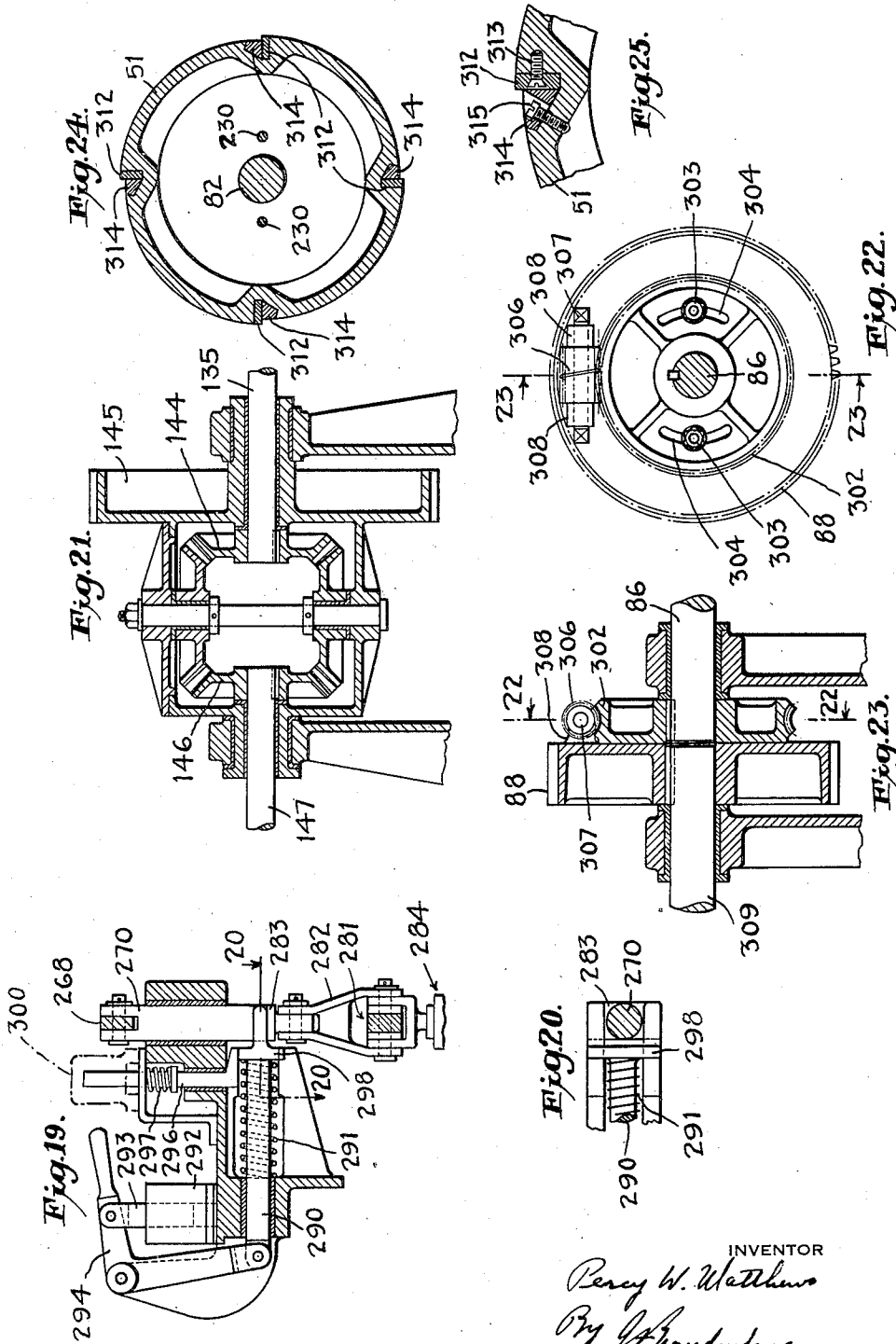
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FLYING SHEAR

Original Filed Feb. 26, 1934 11 Sheets-Sheet 6



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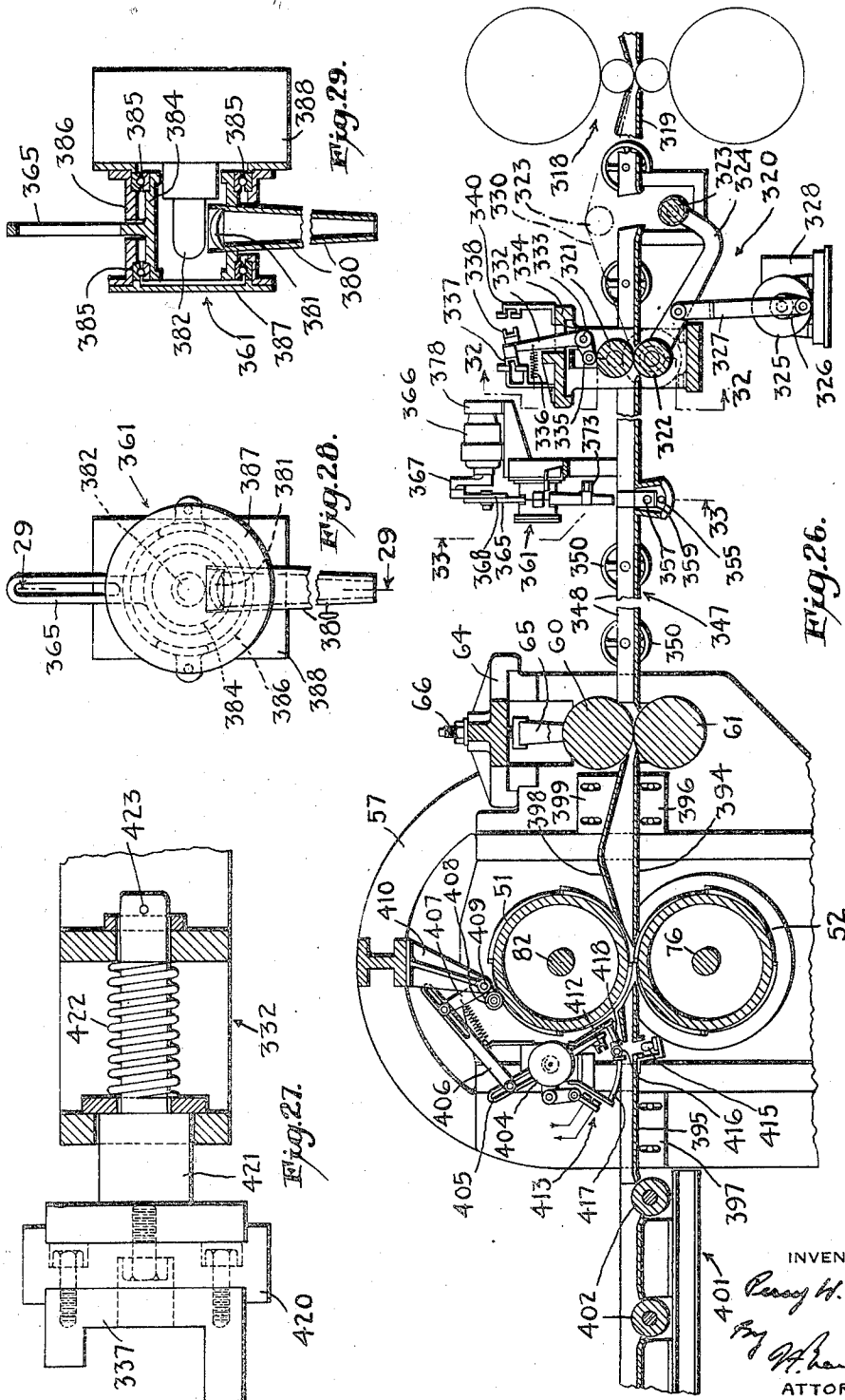
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Original Filed Feb. 26, 1934 11 Sheets-Sheet 8

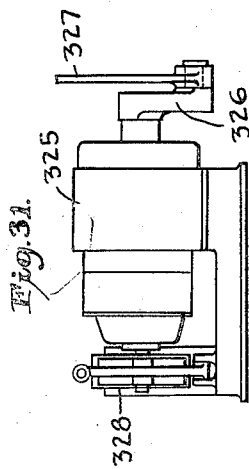
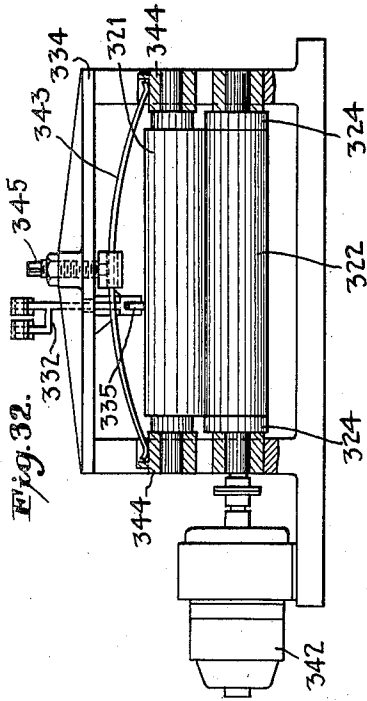


Fig. 30.

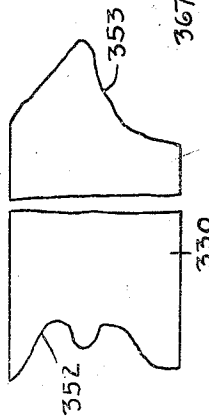
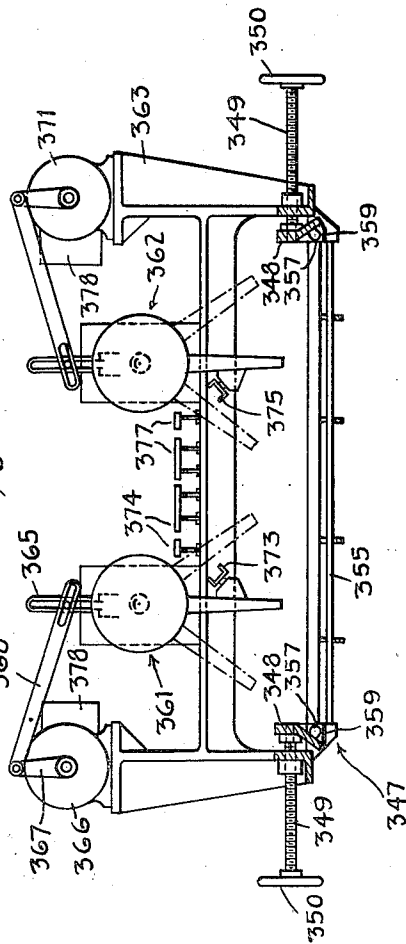


Fig. 33.



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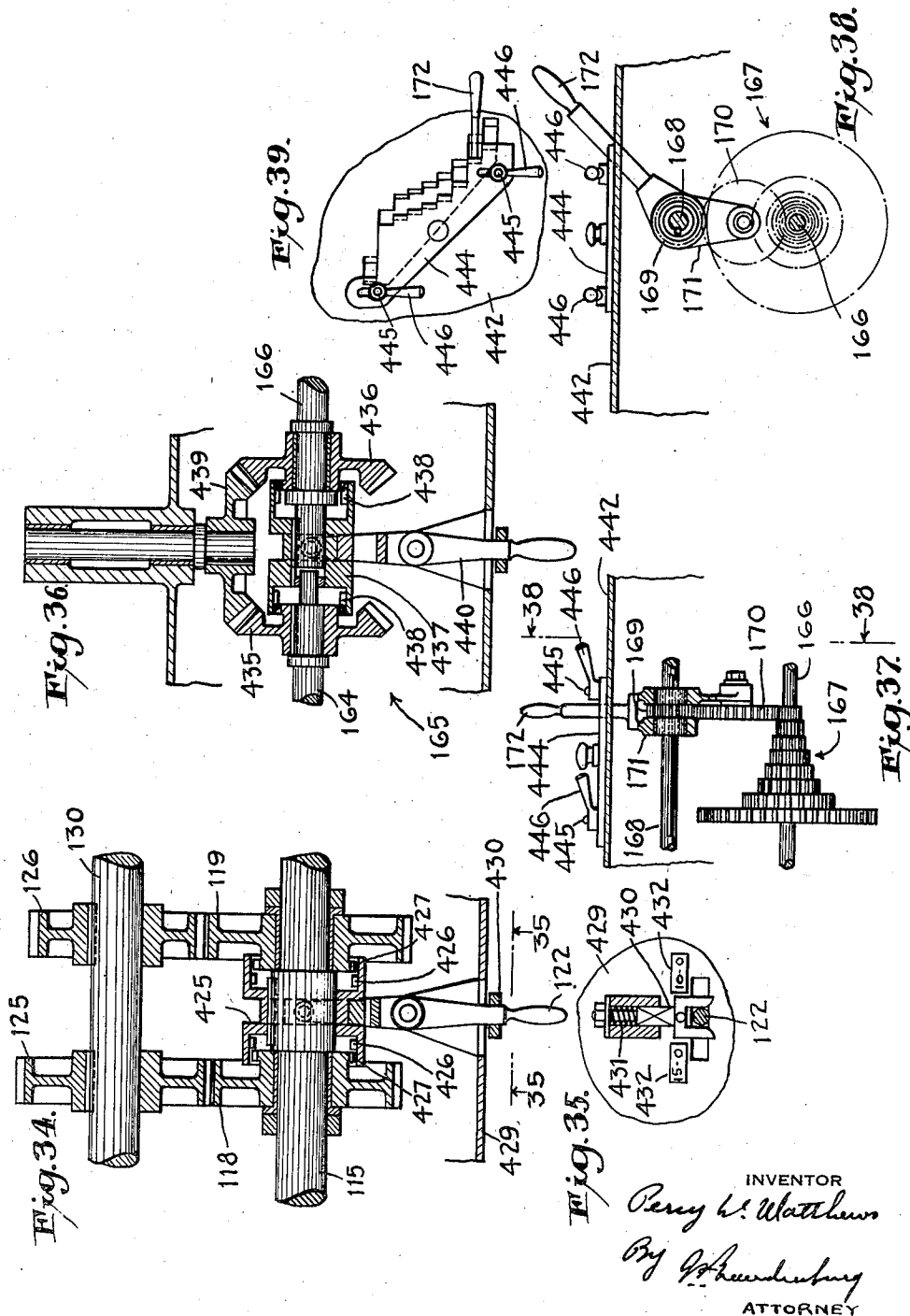
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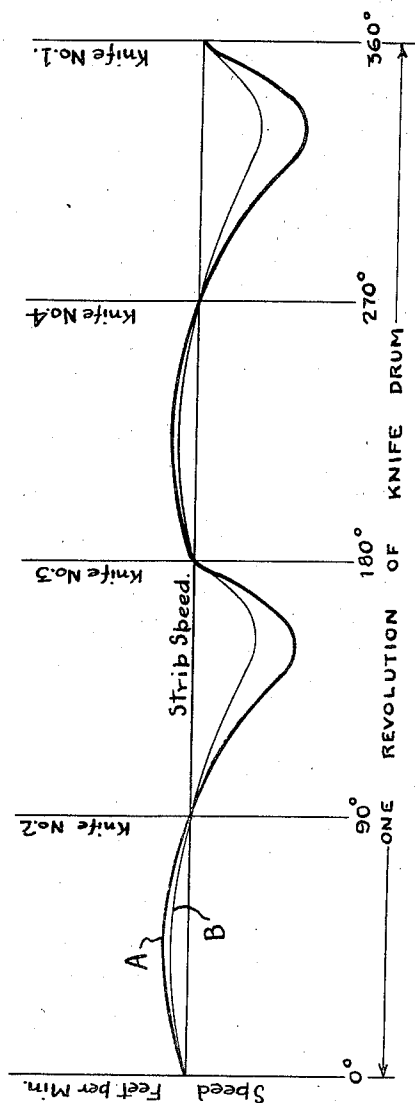


Fig. 40.

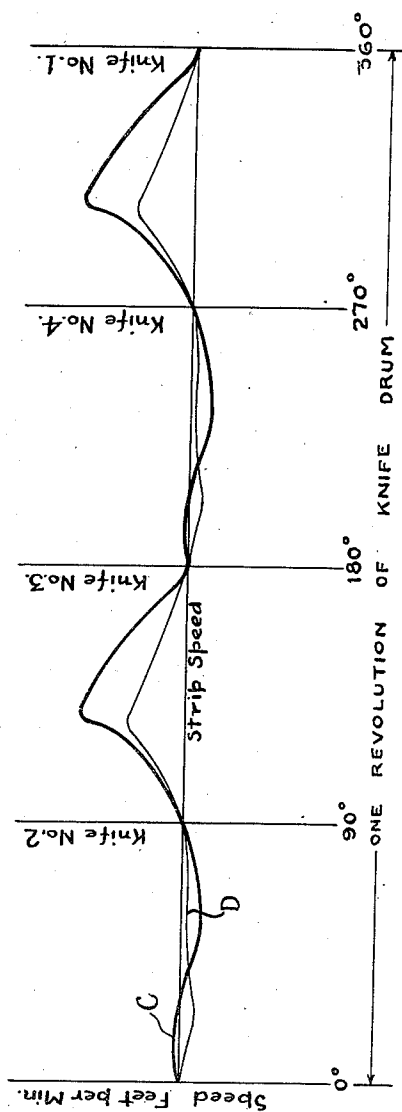


Fig. 41.

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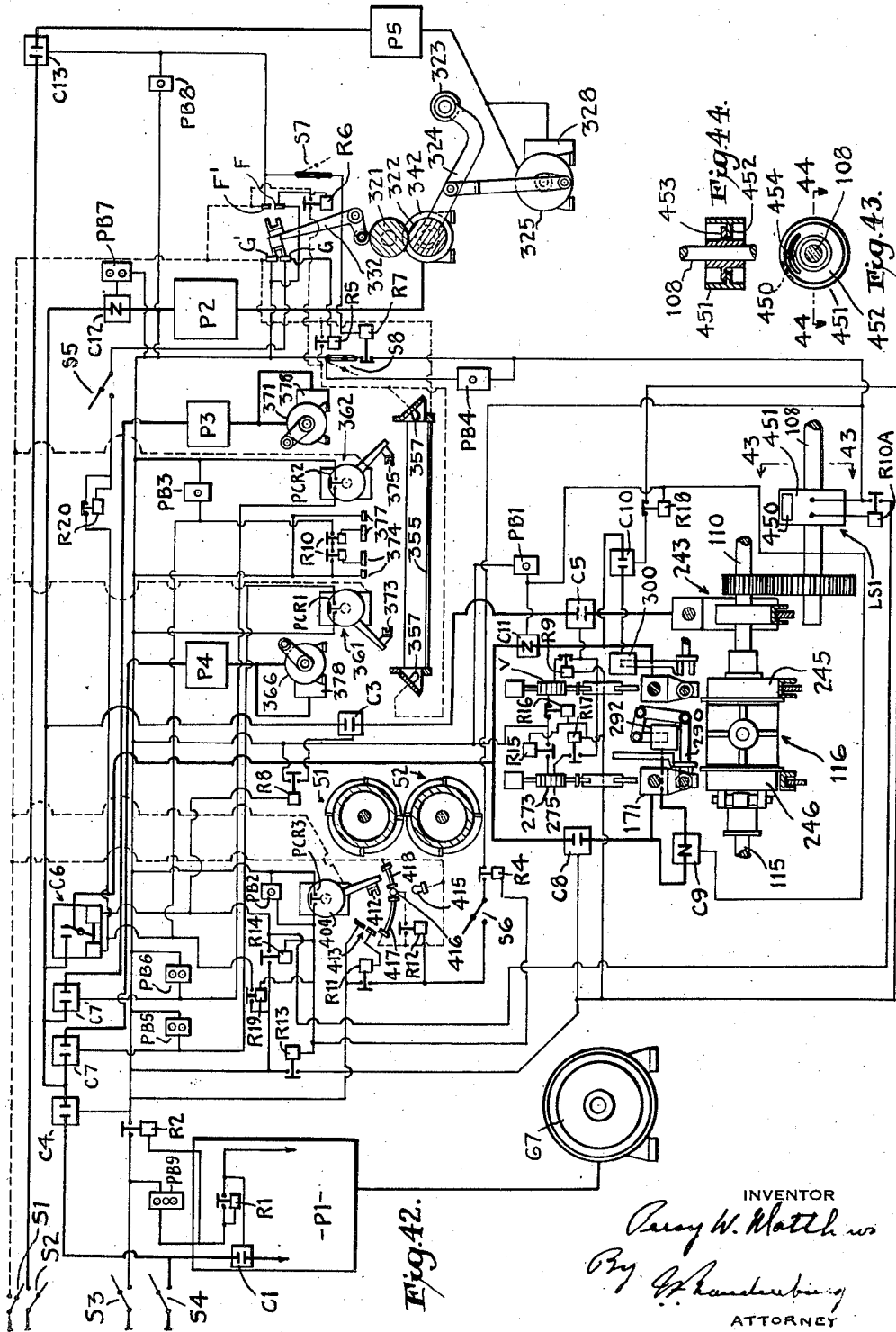
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2,070,537

FLYING SHEAR

Original Filed Feb. 26, 1934 11 Sheets-Sheet 11



UNITED STATES PATENT OFFICE

2,070,537

FLYING SHEAR

Percy W. Matthews, Pittsburgh, Pa., assignor, by direct and mesne assignments, of thirty-eight one-hundredths to Edgar J. Griffiths, Pittsburgh, Pa., nineteen one-hundredths to Joseph F. Brandenburg, Larchmont, N. Y., and five one-hundredths to Charles W. Neill, West Englewood, N. J.

Application February 26, 1934, Serial No. 712,938
Renewed July 9, 1936

46 Claims. (Cl. 164—68)

This invention relates to machines for cutting moving stock of various kinds and compositions, and particularly to flying shears adapted for cutting strip or sheet metal coming from a rolling mill, but the invention is not limited to such use.

An object of the invention is to provide a flying shear in which a cutting knife damaged during the operation of the flying shear can be replaced with a new knife without stopping the shear and without interfering with the delivery of the material. It is an object of the invention to change knives quickly and thereby limit the length of material which passes through the shear during the knife-changing operation. According to one feature of the invention the knife changing is entirely automatic and controlled by electric means which detects a damaged knife by its imperfect cutting action.

Another object of the invention is to provide a flying shear with automatic control means for causing the knives to shear the strip material immediately after the passage of an irregular front end, and to continue to shear the strip, as it comes from the mill, into desired lengths. The invention provides novel control means for shearing off an irregular front or rear end of a strip and thereafter throwing the knife drums into a non-shearing position and holding them in such position, or for obtaining automatic or manual control of subsequent shearing operations, or automatic starting or stopping of the shearing operations by the knife drums when the end of a strip enters or leaves the flying shear.

Another object of the invention is to provide improved mechanism for driving the various parts of the shear, including novel means for accelerating or decelerating the drums to strip speed, and for causing relative movement of the drums toward and from one another to make a cut. The driving mechanism includes two sets of gearing between the knife drums and feed rolls of the shear, and mechanism by which the speed of one set of gearing can be either added to or subtracted from that of the other set to obtain a great number of speed ratios between the knife drums and feed rolls for cutting strips of different lengths.

The novel mechanism of this invention for accelerating or decelerating the knife drums con-

verts a constant rotative speed of the drum driving arms into a variable drum speed which synchronizes the knife speed with the strip speed at the instant the cut is made. Relative movement of the knife drums toward and from one another to make a cut is produced by a novel combination of eccentrics which obtains rapid movement of the knives and a short radius of gyration for the operating parts and a balancing of the load to be moved.

Another object of the invention is to provide novel control mechanism including a swinging finder containing a photo tube which is influenced by the presence or absence of light along the path over which the finder swings. In this invention such finders detect the passage of an irregular front or rear end, and detect a damaged knife by its failure to completely sever the strip.

Other objects, features and advantages of the invention will appear or be pointed out as the specification proceeds.

In the accompanying drawings, forming part hereof:

Fig. 1 is a diagrammatic view, mostly in section, showing a flying shear embodying the invention.

Fig. 2 is an enlarged side elevation of the flying shear shown in Fig. 1, looking toward the left.

Fig. 3 is a sectional view on the line 3—3 of Fig. 2.

Figs. 4 and 5 are enlarged sectional views on the lines 4—4 and 5—5 in Figs. 2 and 3, respectively.

Fig. 6 is a sectional view on the line 6—6 of Fig. 2.

Fig. 7 is a vertical sectional view through the upper knife drum and its driving mechanism.

Figs. 8 and 9 are enlarged sectional views on the lines 8—8 and 9—9, respectively, of Fig. 7.

Fig. 10 is an end view taken on the line 10—10 of Fig. 7.

Fig. 11 is a bottom plan view of the structure shown in Fig. 10.

Fig. 12 is an enlarged fragmentary detail view of one of the knives.

Fig. 13 is an end view of the differential unit for changing from one set of knives to the other.

Fig. 14 is a sectional view on the line 14—14 of Fig. 13.

Fig. 15 is a fragmentary elevation showing the

latching drum of the differential unit of Figs. 13 and 14.

Fig. 13 is a sectional view taken on the line 16—16 of Fig. 15.

Fig. 17 is a sectional view through one of the latching drums, the section being taken on the line 17—17 of Fig. 14.

Fig. 18 is a fragmentary horizontal sectional view of a portion of the brake and latch mechanism.

Figs. 19 and 20 are enlarged sectional views taken on the lines 19—19 and 20—20, respectively, of Figs. 13 and 19, respectively.

Fig. 21 is an enlarged sectional view taken on the line 21—21 of Fig. 1.

Fig. 22 is an enlarged sectional view taken on the line 22—22 of Fig. 1, and is also a sectional view taken on the line 22—22 of Fig. 23.

Fig. 23 is a sectional view taken on the line 23—23 of Fig. 22.

Fig. 24 is a vertical sectional view of one of the knife drums.

Fig. 25 is an enlarged detail view showing the connection of one of the knives to the drum.

Fig. 26 is a fragmentary vertical sectional view through the flying shear and feed means with the apparatus for detecting incomplete cuts and for finding the full width of the sheet when making front and rear end cuts.

Fig. 27 is an enlarged view of a portion of the switch mechanism.

Fig. 28 is an enlarged end view of one of the swinging finders shown in Fig. 26.

Fig. 29 is a sectional view taken on the line 29—29 of Fig. 28.

Fig. 30 is a plan view of the material as it comes from the mill, showing typical irregular front and rear ends.

Fig. 31 is an enlarged view of the motor and operating connections of the looping unit shown in Fig. 26.

Figs. 32 and 33 are enlarged views, partly in section, taken along the lines 32—32 and 33—33, respectively, in Fig. 26.

Fig. 34 is an enlarged sectional view showing some of the driving gears of Fig. 1.

Fig. 35 is a sectional view taken on the line 35—35 of Fig. 34.

Fig. 36 is an enlarged sectional view of a part of the control mechanism shown in Fig. 1.

Fig. 37 is an enlarged view of one of the gear changing mechanisms shown in Fig. 1.

Figs. 38 and 39 are end and top plan views, respectively, of the gear changing mechanism shown in Fig. 37.

Figs. 40 and 41 are diagrams showing the changes in the peripheral speed of the knife drums when driving with the mechanism shown in Figs. 8 and 9, respectively.

Fig. 42 is a schematic view of the control devices with their electric circuits.

Fig. 43 is a sectional view along the line 43—43 of Fig. 42.

Fig. 44 is a sectional view taken on the line 44—44 of Fig. 43.

Referring to Fig. 1, the flying shear has knife drums 51 and 52 operatively connected by gears 53 and 54 to run at the same speed. These drums constitute rotary knife-carriers. The knife drum 51 rotates in bearings in slides 55 and 55' at opposite ends of the drum. The knife drum 52 rotates in bearings in slides 56 and 56'. All of these slides are vertically movable in guideways in a main frame 57.

Sheet material is supplied to the flying shear by

feed rolls 60 and 61 having their opposite ends journaled in bearing blocks 62 and 63. The blocks 62 are movable in slots in a supporting frame 64, and a spring 65 is held against the bearing blocks 62 by a screw 66. The spring 65 urges the roll 60 toward the roll 61 and the tension of the spring can be varied by turning the screw 66, which threads through the top of the frame 64.

The knife drums 51, 52 and feed rolls 60, 61 are rotated by a common motor 67, which is coupled to a shaft 68. A fly-wheel 69 and pinion 70 turn with the shaft 68.

The motor 67 drives the knife drums 51 and 52 through a gear 71 meshing with the pinion 70 and connected by a shaft 72 with a pinion 73 which drives a gear 74 secured to a drive shaft 75.

A shaft 76 is supported by bearing blocks 77 and extends through the hollow interior of the knife drum 52. A spindle 78 has universal jaws 79 at its opposite ends connecting it with a shaft 80 and the shaft 76, respectively. The driving connections between the shaft 76 and the knife drum 52 will be explained in detail in the description of Figs. 7—11. The shaft 80 is connected with the drive shaft 75 by a coupling unit 81.

The upper knife drum 51 is driven from a shaft 82 which extends through the upper knife drum and is supported in bearing blocks 83. A spindle 84 has universal jaws 85 at its opposite ends connecting it with the shaft 82 and a shaft 86, respectively, the latter shaft being driven from the coupling unit 81 through a coupling unit 87. These coupling units 81 and 87 have gears 88 and 89, respectively, which mesh with one another, and these units will be explained in detail in describing Figs. 22 and 23.

When the shears are used to cut lengths equal to the circumference of the knife drums 51, 52, the drums are rotated at a uniform speed with the peripheral speed of the knife drums equal to the lineal speed of the sheet material through the feed rolls and shear. When the lengths to be sheared are greater or less than the circumference of the knife drums, these drums are rotated at a variable speed so that the speed of the knives is equal to that of the sheet material at the time of shearing, but less or greater during the remaining part of each revolution.

This variable rotative speed of the knife drums is obtained by moving the bearing blocks 77 and 83 vertically so that the axes of the shafts 76 and 82 are slightly above or below the axes of the knife drums. The driving connections between the shafts 76 and 82 and the knife drums 51 and 52, respectively, have a novel crank movement which produces the variable rotative speed of the knife drums, as will be more fully considered in connection with Figs. 40 and 41 of the drawings. The mechanism for moving the bearing blocks 77 and 83 vertically will be explained in the description of Figs. 2—4.

The knife drums are moved toward one another when knife blades on the drums are in position to shear the material, by eccentrics which turn in timed relation to the knife drums and move the slides 55 and 56 vertically in opposite directions. The gears 53 and 54 are designed to operate with variations in the distance between their axes.

An eccentric 92 extends through the lower end of each of the slides 56 and 56' and rotation of these eccentrics causes vertical movement of the slides 56 and 56' and knife drum 52. Each of the eccentrics 92 is integral or rigidly connected with a short shaft 93. Each of these

shafts 93 has a gear 94 through which the shafts are driven by gears 95 (Fig. 2) on a driving shaft 96.

Referring again to Fig. 1, the slides 55 and 55' are moved vertically by eccentrics 97 on short shafts 98, which are rotated by gears 99 from the driving shaft 96.

Each of the short shafts 93 is journaled in a yoke 101, and each of the short shafts 98 is journaled in a yoke 102. The lower ends of the yokes 101 and 102 cooperate with timing eccentrics 103 and 104, respectively, and these timing eccentrics cause a vertical up and down movement of the yokes, shafts 93 and 98, and the eccentrics carried by them. The timing eccentrics 103 and 104 are integral or connected with shafts 106, which turn in bearings in the frame of the machine and are connected together at the center of the machine by a coupling 107. One of the shafts 106 is coupled to a driving shaft 103.

The shaft 96 is driven through a coupling connecting it directly to a shaft 110, and power from this shaft 110 is transmitted to the eccentric driving shaft 108 through gears 111 and 112. These gears have a speed ratio of 2 to 1 so that the shaft 110 turns twice as fast as the eccentric driving shaft 108. This gear ratio is illustrative and other ratios may be used with shears designed to cut a different range of lengths.

The eccentrics move one knife drum up at the same time that they move the other knife drum down so that the load on the eccentric driving mechanism is mostly a friction load, because the weight of one knife drum is balanced against the weight of the other.

The combination of two eccentrics for operating each of the slides is an important feature of this invention. In order to produce with a single cam the fast acceleration of the knives toward and from one another which is obtained by the combined action of two eccentrics, it would be necessary to use a very steep cam and the load would be further from the axis of rotation and require greater driving torque.

A shaft 115 drives the shaft 110 through a differential unit 116. The construction and operation of this unit will be explained later. The function of this unit is to change knives and this is accomplished by causing relative rotation of the shafts 115 and 110 through the correct angle which will change the relation of the angular positions of the eccentrics with respect to the angular positions of the knife drums so that the eccentrics bring the drums together when different knives are in cutting position.

Gears 118—121 on the shaft 115 each have a clutch by which they can be connected to the shaft 115. A clutch handle 122 is shown in its middle neutral position in Fig. 1. With the clutch handle in this position the gears 118 and 119 are both free to turn independently of the shaft 115. Shifting the handle 122 to the right clutches the gear 118 to the shaft, and shifting the handle to the left clutches the gear 119 to the shaft. A clutch handle 123 between the gears 120 and 121 can be operated to clutch either of these gears to the shaft 115. Only one of these gears 118—121 is clutched to the shaft 115 at any time, the choice depending on the desired gear ratio between the motor 67 and the shaft 115.

The gears 118—121 mesh with gears 125—120, respectively, on a shaft 130 which is driven from the shaft 72 through gears 131 and 132.

The gear ratio between the motor 67 and the knife drums is constant, and therefore the speed

ratio between the knife drums and the eccentrics depends upon which of the gears 118—121 is clutched to the shaft 115. When the gear 118 is clutched to the shaft 115 in Fig. 1, the knife drums make one revolution while the timing eccentrics 103 and 104 make one revolution.

When the gear 119 is clutched to the shaft 115, the knife drums make one and one-half revolutions for each revolution of the timing eccentrics. When driving the shaft 115 through the gears 120 10 and 121, the knife drums make two and two and one-half revolutions, respectively, for each revolution of the timing eccentrics 103 and 104.

The knife drums are brought together to shear the material once with each revolution of the timing eccentrics 103 and 104. There are four knives evenly spaced around the circumference of each knife drum. When the drums are making 1 or 2 revolutions for each revolution of the timing eccentrics, the same knives will be in shearing position each time the drums are brought together to make a cut. When the drums are making 1½ or 2½ revolutions between each shearing operation the cuts will be made alternately with opposite knives, as for example, with the first and third knives of each drum.

The shear may be set up to cut with the first knife, or first and third knives, depending on the speed ratio used. On none of the available speed ratios will the second or fourth knives come into use when the shear is set up to cut with the odd numbered knives. If the first or third knife on either drum breaks or becomes defective, so that the material is not cut across its entire width, automatic means, which will be explained hereinafter, operate the differential unit 116 to change the relative positions of the timing eccentrics and knife drums so that the eccentrics move the drums together to shear the material when the second or fourth knives of the drums are in shearing position. This knife-changing operation is performed quickly while the shear is running. After changing to the new knife, the shear continues to cut sheets of the same length as were cut by the first knife.

The feed rolls 60 and 61 are driven from the motor 67 through gear mechanisms which make it possible to change the gear ratio between the motor 67 and the feed rolls by very small increments through a wide range, and these increments are uniform over the whole cutting range of the shear. Since the gear ratio between the motor 67 and the knife drums 51, 52 is constant, the gear changing mechanism between the motor 67 and the feed rolls 60, 61 changes the speed ratio between the knife drums and the feed rolls and determines the length of material passing between the drums for each shearing operation. The flying shear shown in the drawings can be set to cut sheets of any length between ten and twenty-five feet by increments of one-eighth inch.

The feed roll 61 is coupled to a driving shaft 135, and the feed roll 60 is driven from this driving shaft 135 through gears 136 and 137, a shaft 138, and a spindle 139 connected at its ends to the shaft 138 and feed roll 60 by universal jaws 140. The driving shaft 135 is rotated through differential gearing 142, which includes a bevel gear 144 (Fig. 21) fixed to the shaft 135, a ring gear 145, and a bevel gear 146 fixed to a shaft 147.

Referring again to Fig. 1, the shaft 147 is driven by the shaft 130 through two sets of bevel gears 150 and 151 and a connecting shaft 152.

The ring gear 145 meshes with a gear 154 fixed to a shaft 155. The shaft 155 is driven from a

shaft 156 through a reverse gear 157, and the shaft 156 is connected with a gear shaft 158 by differential gearing 159. This differential gearing is similar in construction to the differential gearing 142 and includes a bevel gear fixed on the shaft 156, a ring gear 160, and a bevel gear fixed to the gear shaft 158. A set of gears 162, of different sizes, is fastened to the gear shaft 158.

The ring gear 160 is driven by a gear 163 on a shaft 164, which is driven through a reverse gear 165 by a gear shaft 166. A set of different size gears 167 is fixed on the gear shaft 166.

The set of gears 167 is rotated from a shaft 168 through a gear 169 splined on the shaft 168 and an idler 170. The idler 170 is carried by an axle extending from an arm 171 which is slidable and rotatable on the shaft 168. The arm 171 extends on both sides of the gear 169 and has a handle 172 by which it is moved to bring the idler 170 into mesh with any one of the gears 167. This mechanism is shown more completely in Figs. 37-39, and will be more fully explained in describing those views.

The set of gears 162 is driven from a shaft 174 by a splined gear and idler 175 similar to the gear mechanism between the set of gears 167 and the shaft 168 already described.

There are two gears 176 and 177 on the shaft 174, and either of these gears can be clutched to the shaft 174 by operating a clutch handle 178. These gears 176 and 177 are driven by gears fixed on a shaft 179, which is operatively connected with the shaft 168 through countershafts 180 and 181 and the connecting gears shown in Fig. 1. The shaft 179 is driven from the gear shaft 115 through a gear train 182.

The shaft 147 has a fixed gear ratio with the knife drums, and when the ring gear 145 is stationary, the shaft 135 turns in the opposite direction and at the same speed as the shaft 147, and the feed rolls 61 and 60 run at the same speed as the shaft 147. By rotating the ring gear 145 in one direction or the other the speed of the shaft 135 is made greater or less than that of the shaft 147, and the ratio of the feed roll speed to that of the knife drums is changed so that more or less sheet material passes between the knife drums for each shearing operation. The reverse gears 157 and 165 make it possible to use the mechanism which drives the gear 154 to rotate the ring gear 145 either way and add to or subtract from the speed of the shaft 135.

The speeds of the knife drums and feed rolls are proportioned so that the exact length of material to be sheared is delivered by the feed rolls while the knife drums turn through 1, $1\frac{1}{2}$, 2 or $2\frac{1}{2}$ revolutions. The drums are in cutting position on multiples of $\frac{1}{2}$ revolution and when cutting sheets of any desired length the gearing is set to cause the knife drums to make the number of half revolutions which causes the peripheral speed of the knife drums to most nearly equal the lineal speed of the strip through the feed rolls 60 and 61. For example, if the circumference of the knife drums is ten feet and sheets of ten foot length are to be cut, the gearing is set so that the knife drums make one revolution while ten feet of strip passes through the feed rolls.

If sheets eleven or twelve feet long are to be cut, the gears are set so that eleven and twelve feet of strip, respectively, pass through the feed rolls for each revolution of the knife drums. When cutting sheets thirteen feet long, however, the peripheral speed of the knife drums more nearly

approximates that of the strip if the drums make $1\frac{1}{2}$ revolutions while thirteen feet of strip material pass through the feed rolls. When cutting twelve and one-half foot sheets there is no preference between one and one and one-half drum revolutions for twelve and one-half feet of strip passing through the feed rolls, because the peripheral drum speed is just as far removed from the strip speed in either case.

For sheets between twelve and one-half and seventeen and one-half feet long, the knife drums make $1\frac{1}{2}$ revolutions while the length of strip to be cut passes through the feed rolls. When cutting sheets between seventeen and one-half and twenty-two and one-half feet long, the knife drums make 2 revolutions while the length of material to be cut passes through the feed rolls.

The strip material can pass freely between the knife drums when they are separated, but it is necessary that the knives and strip be moving at the same speed during the actual shearing operation. When cutting ten, fifteen, twenty and twenty-five foot lengths, the knife drums rotate at constant speed, making 1, $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ revolutions, respectively, while the length of material to be cut passes through the feed rolls. For all other sheet lengths it is necessary to increase or decrease the drum speed to that of the strip during that part of the drum revolution when the knives come together to make the cut.

Variable knife drum velocities are obtained by moving the axes of the shafts 76 and 82 out of coincidence with the axes of their respective knife drums 52 and 51. The mechanism for raising and lowering the shafts 76 and 82 is shown in Figs. 1-4. Each of the bearing blocks 77 has a screw 184 which is non-rotatably connected to the bearing block, as shown in Fig. 4. The lower end of the screw threads into a sleeve 185, rotatably supported in a cross head 186, and connected by a bolt 187 to a bracket 188 which extends out from the slide 56. The sleeve 185 is free to rotate with respect to the bolt 187.

A gear 189 is splined on the sleeve 185 and is located in a slot 190 in the cross head 186, so that the sides of the slot prevent axial movement of the gear. When the gear 189 turns the sleeve 185, the screw 184 is moved up or down, depending on the direction of rotation of the gear and sleeve, and raises or lowers the bearing block 77.

The bearing blocks 83 each have two rods 192 which extend down on opposite sides of the bearing block 77. These rods 192 have their lower ends threaded into sleeves in the cross head 186, the construction being similar to that shown in Fig. 4. Gears 193 and 194, which raise and lower the rods 192, mesh with the gear 189, as shown in Fig. 2. The gears 193 and 194 turn in the same direction as one another and in the opposite direction to the gear 189. The screw 184 has the same threads as the rods 192 so that the rotation of the gears 193, 194 and 189 causes the blocks 77 and 83 to move in the opposite direction.

The gears 193, 194 and 189 are rotated by a gear 196 which meshes with the gear 194, and is keyed to a shaft 195 on the cross head 186. A worm wheel 196', keyed to the shaft 195, is rotated by a worm 197 on a shaft 198, best shown in Fig. 5.

The mechanism thus far described for moving the bearing blocks 77 and 83 is the same on both sides of the machine. The two shafts 198 (Fig. 1) are connected together at the center of the machine by a coupling 199 so that the mechanisms on both sides work together. A hand-wheel 200 is fastened to the end of the right-hand shaft 198,

and this hand-wheel is used by the operator to adjust the positions of the shafts 76 and 82.

A pointer 201 operating over a scale 202 just above the hand-wheel indicates the position of the shafts. The scale is attached to the main frame 57 and the pointer 201 is pivoted on a stud 203 extending from the main frame. One end of the pointer is forked and fits over a pin 204 carried by the block 77. Vertical movement of this pin 204 with the block 77 operates the pointer.

Fig. 7 is a section through the upper knife drum 51. The right-hand bearing of this knife drum comprises a housing 206 for the driving arms by which the shaft 82 rotates the knife drum. There is a web 207 on the inside of the housing 206, and this web has driving lugs 208 on its right side and driving lugs 209 on its left side.

A sleeve 210 on the shaft 82 is prevented from turning on the shaft by keys 211 (Figs. 7-9), but is movable axially along the shaft. Driving arms 212 and 213 are integral or rigidly connected to the sleeve 210. There are two driving arms 212 (Fig. 8) and each has a roller 214 for contacting with the adjacent driving lug 208. The rollers 214 are diametrically opposite one another with respect to the shaft 82.

Shock absorbers prevent the driving arm rollers 214 from coming against the driving lugs 208 with violent impact. Each of these shock absorbers includes a roller 215 carried by one end of a bell crank 216, which is pivoted to the driving lug 208. A rod 217 pivoted to the other end of the bell crank 216 extends into a cylinder 218. The head of this cylinder has a pivot connection 219 with a lug on the inside of the housing 206. A coil spring 220 is compressed between one end of the cylinder 218 and a collar on the rod 217.

When the rollers 214 are not in contact with the driving lugs 208, the springs 220 hold the bell cranks 216 in such positions that the driving arm rollers 214, as they move toward the driving lugs 208, contact first with the rollers 215 and can not move up to the driving lugs without rocking the bell cranks 216 and compressing the springs 220. The positions into which the bell cranks are moved, and the amount of compression of the springs 220 depends on the eccentricity of the shaft 82 with respect to the axis of the knife drum.

The bell cranks 216 are connected to the rods 217 in such relation that the movement of the bell cranks 216 by the driving arm rollers 214 reduces the moment arms of the springs 220 and consequently reduces the force from the springs on the driving arms.

When the axis of the shaft 82 coincides with the axis of the knife drum, the rollers 214 both contact with the driving lugs 208 and transmit rotary movement of the shaft 82 to the knife drum without change of speed. If through manufacturing inaccuracy one roller 214 is slightly ahead of the other, it contacts with one of the driving lugs during the entire rotation of the shaft 82 and transmits the constant speed rotation of the shaft to the knife drum.

When the axis of the shaft 82 is higher, and farther from the cutting knife than the axis of the knife drum, one of the driving arms 212 transmits the rotary movement of the shaft 82 to the knife drum during $\frac{1}{2}$ revolution and the other driving arm transmits the movement during the next half revolution. Since the distance from the axis of the knife drum to the point of contact of the driving roller 214 on the driv-

ing lug 208 changes as the shaft 82 turns, the angular speed of the motion transmitted to the knife drum is variable. The greater the eccentricity of the shaft 82 in the knife drum, the greater the variations in the speed at which the knife drum is rotated.

The driving lug faces with which the rollers 214 contact are cam faces, and the variations in drum speed for a given eccentricity of the shaft 82 depend on the shape of these faces, particularly their slope with respect to radii from the axis of the knife drum.

The variations in the drum speed for maximum eccentricity of the shaft 82, and with the shaft in a position equivalent to one-half of its maximum eccentricity, are shown in Figs. 40 and 41, and this variable speed operation will be more fully described in the explanation of those views.

The arms 213 have rollers 222 which contact with cam faces on the driving lugs 209 to transmit rotary movement of the shaft 82 to the knife drum. The driving arms 212 and 213 are spaced axially on the sleeve 210 so that when the driving arms 212 are in position to contact with the driving lugs 208 the driving arms 213 are far enough to the left in Fig. 7 to rotate without coming in contact with the driving lugs 209.

The knife drum is driven by the driving arms 212 when the average peripheral speed of the drum is less than the lineal speed of the strip, and it is therefore necessary to speed up the drum for each shearing operation. When the average drum speed is higher than the strip speed, the driving arms 213 are used to rotate the drum so that it slows down for each shearing operation.

The sleeve 210 is shifted axially to the right in Fig. 7 to shift the drum drive from the driving arms 212 and their cooperating lugs shown in Fig. 8 to the driving arms 213 and lugs 209 shown in Fig. 9.

An S-link 224 has one end pivoted at 225 to each of the lugs 209. The other end of each link 224 is connected with the housing 206 by a toggle link 226, the center pivot of which is connected with a rod 227 extending into a cylinder 228 similar to the cylinder 220 shown in section in Fig. 8. A roller 229 carried by each link 224 contacts with one of the driving arm rollers 222, and in combination with its connected links and a spring in the cylinder 228 serves as a shock absorber for preventing the driving arm roller 222 from coming against the driving lug with violent impact.

The mechanism for moving the sleeve 210 to shift from the drum drive mechanism of Fig. 8 to that shown in Fig. 9 includes rods 230 which have their ends threaded through the driving arms 213. These rods extend along opposite sides of the shaft 82 to the left end of the drum in Fig. 7 where they pass through the opposite sides of a double arm 232, best shown in Figs. 10 and 11.

A bevel gear 233 on the end of each rod 230 meshes with a bevel gear 234 on one end of a short shaft 235 extending through a bracket on the double arm 232. The other end of the shaft 235 has a square end for receiving a wrench. The double arm 232 is keyed to the shaft 82 and turns as a unit with the shaft.

Gears 236 fixed on the rods 230 mesh with an idler gear 237 on the shaft 82. Rotary movement of either of the rods 230 in either direction is transmitted through the idler gear 237 to the other rod 230.

The bevel gear 233 fixed on each rod 230 against one face of the double arm 232, and a collar 238 fixed on the rod against the opposite face of the double arm, prevent axial movement of the rod. Since these rods 230 can not move axially with respect to the shaft 82, their rotation causes the sleeve 210 to be shifted along the shaft in one direction or the other, depending on the direction of rotation of the rods.

Fig. 12 is an enlarged fragmentary view of one of the knives. The knife has a taper or rake so that as it comes into shearing relation with the cooperating knife on the other drum it shears the material first at the left or high side of the knife and then progressively across the width of the material as the knife drums move closer together. This progressive cut reduces the load which is imposed on the driving mechanism when shearing the material as compared with a flat knife which cuts the full width at the same time. The fast and extensive knife drum movement obtained by the double eccentrics of this invention makes it possible to shear the material progressively and still obtain a small bite angle. The bite angle is the angle through which the knife drums turn during the shearing operation.

Figs. 13 and 14 show the construction of the differential unit 116 (Fig. 1) by which the angular positions of the knife drums with respect to the eccentrics are changed to cause the eccentrics to bring the drums together to shear with different knives from those originally chosen before starting the shear. Fig. 14 shows the shafts 110 and 115 extending through bearings in the rotatable housing of the differential unit with bevel gears 240 and 241, respectively, fixed on the ends of these shafts inside the housing. These bevel gears 240 and 241 mesh with idler gears 242 carried by the rotatable housing which corresponds to the ring gear of an ordinary automotive differential. A brake 243 is applied to the shaft 110 whenever power is supplied to the solenoid which operates this brake.

The differential unit has a removable side 244, which is tightly closed to retain lubricant within the housing. Brake drums 245 and 246 are formed on the right and left ends, respectively of the housing. The brake drum 245 has recesses in which latching blocks 247 (Fig. 17) are secured in position to receive a latch for stopping and holding the brake drum and differential unit in the position which gives the correct relation between the knife drums and eccentrics when knives 1 and 3 are to be used for shearing.

The brake drum 246 is slotted and has latch blocks 249 (Fig. 16) for receiving a latch to stop and hold the brake drum and differential unit in the correct position for cutting with knives 2 and 4 of the knife drums. The latch blocks 249 are not connected directly to the brake drum 246, but are bolted to a drum 250 which is located inside of the brake drum and rotatable with respect to the brake drum about the axis of the differential unit.

The drum 250 is connected to the housing of the differential unit by a bolt 251 which extends through an arcuate slot 252. A worm 253 is fixed on a shaft 254 which turns in lugs 255 extending from the brake drum 246. This shaft has square ends for receiving a tool. The worm engages teeth of a worm-wheel segment 256 extending from the drum 250. When the bolt 251 is tight, the drum 250 is rigidly connected with the hous-

ing and the brake drum 246. When the bolt 251 is loosened, the shaft 254 and worm 253 can be rotated to change the angular relation of the drum 250 and brake drum 246.

In order to prevent a latch from dropping into the slot in the brake drum 246 before reaching the latch block 249, central wings 258 extend from both the front and back of the latch block. The slot in the brake drum has narrow extensions at both ends. These extensions are wide enough to receive the wings 258, but too narrow for the latch to enter.

The friction brakes for the drum 250 are shown best in Fig. 13. There is similar mechanism for the brake drum 245. Brake levers 260 and 261 have pivot connections with lugs of a base 262. Brake shoes 263 and 264 have pivot connections with the brake levers 260 and 261, respectively. Screws 266 threading through the brake levers and contacting with the brake shoes hold these shoes in such positions that they contact the drum with substantially uniform pressure when applied, and do not drag on the drum when released.

The top ends of the brake levers are drawn together to apply the brake by a bell-crank 268 pivoted between its ends to the brake lever 260 and having one end connected to the brake lever 261 by a link 269.

The bell-crank 268 is connected with a plunger 270 by a pin extending through a substantially horizontal slot in the bell-crank. A solenoid 271 has its armature connected with the bell-crank 268 by a link 272.

An electric contact 273 is carried on the lower end of a rod which is connected to one end of the bell-crank 268 by a link 274. A second electric contact 275 is held against the contact 273 by a spring 276. This second contact is connected with a dash-pot 277 which delays the upward movement and causes the contacts to remain apart for a period when movement of the bell-crank 268 causes the contact 273 to move upward away from the contact 275.

A latch 280 is moved toward and from the brake drum 246 by a toggle 281. The joint of the toggle is connected with the lower end of the plunger 270 by a link 282. The plunger 270 has a flange 283 just above its connection with the link 282. A telescopic link 284 is connected at its upper end to the joint of the toggle 281 and at its lower end to a lug on the base 262. A spring compressed in the telescopic link 284 urges the joint of the toggle 281 upward to straighten the toggle and move the latch 280 into the recessed latching blocks of the drum 246. When the solenoid 271 is energized it moves the parts into the positions shown in Fig. 13, so that the latch 280 is withdrawn from the brake drum and the brake released.

A spring 285 between the brake lever 260 and the fixed frame of the machine absorbs the shock from the latch 280 when it drops into a recess in the brake drum 246. When the latch 280 brings the brake drum and differential unit to rest, the force of impact is transmitted from the latch to the brake lever 260, by which the latch is supported, and tends to rock the brake lever counter-clockwise about its pivot connection with the frame 262. The spring 285 resists such movement of the brake lever, but yields to absorb the shock.

The brake mechanism for the brake drum 245 is the same as the structure shown in Fig. 13. Certain differences, not shown in this view, between the respective brake mechanisms for the

drums 245 and 246 will be explained in describing Fig. 19.

Fig. 18 is a horizontal sectional view showing the latch and toggle for the brake drum 245. This view has been turned around with respect to Fig. 13, but the latch 287 and toggle 288 shown in Fig. 18 correspond to the latch 280 and toggle 281 in Fig. 13.

Fig. 19 shows the mechanism for holding the brake released from the brake drum 246. A locking fork 290 extends over the flange 283 and prevents the plunger 270 from being moved up. A compression spring 291 urges the fork 290 into the locking position shown in Fig. 19. The locking fork is withdrawn against the pressure of this spring 291 when the brake is to be applied. A solenoid 292 furnishes the power for withdrawing the locking fork 290. This solenoid has an armature 293 connected with the locking fork by a bell-crank 294.

A latching pin 296 is urged downward by a spring 297 and rests on a collar 298 near the end of the locking fork, but when the locking fork moves to the left in Fig. 19 far enough to permit the plunger 270 to rise, the collar 298 moves beyond the latching pin 296 so that it drops down behind the collar and prevents the spring 291 from moving the locking fork back after the supply of power to the solenoid 292 is cut off.

The mechanism which operates the brake for the drum 245 is similar to that shown in Fig. 19, but it has a solenoid 300 for raising the latching pin which corresponds with the latching pin 296 and it has no solenoid 292 for withdrawing the locking fork which holds the brake released.

Fig. 21 is a sectional view through the differential unit 142 of Fig. 1. The entire gear housing rotates as a unit with the ring gear 145 and serves as a tight enclosure for lubricant in which the bevel gears and idlers run.

Figs. 22 and 23 are enlarged sectional views of the coupling unit 87 shown in Fig. 1. A worm-wheel 302 is fastened on the end of the shaft 86 and is connected with the gear 88 by bolts 303 which extend through arcuate slots 304 in the worm-wheel. When these bolts 303 are tight, the gear 88 and worm-wheel 302 turn as a unit, but when these bolts are loosened the worm-wheel and gear can be moved angularly with respect to one another within the limits imposed by the length of the slots 304.

A worm 306 is fixed to a shaft 307 journaled in lugs 308 extending from the gear 88. The worm 306 meshes with the worm wheel 302, and the ends of the shaft 307 are square so that a wrench can be applied to this shaft to turn the worm wheel and accurately control the relative movement of the gear and worm wheel. The gear 88 is fixed to a supporting shaft 309 supported in suitable bearings.

The coupling unit 81 (Fig. 1) is the same as the coupling unit 87 shown in Figs. 22 and 23, and is adjusted to determine the relative angular positions of the shafts 75 and 80. The adjustment provided for by these coupling units 81 and 87 is necessary to obtain the correct relation between the angular positions of the knife drums and eccentrics because this relation is altered when the bearing blocks 77 and 83 are moved to change the eccentricity of the shafts 76 and 82 with respect to the axes of the drums. After the shafts 76 and 82 are set for a given eccentricity, and before the shear is started, the coupling units 81 and 87 are adjusted, with the eccentrics in the positions occupied at the time of shearing, to

bring the cutting knives into position with their cutting edges in the plane through the axis of both knife drums.

Fig. 24 is a vertical section through one of the knife drums, showing the four knives 312 evenly spaced around the periphery of the drum. Fig. 25 is an enlarged view showing one of the screws 313 by which the knives are fastened to the drum. In addition to screws 313, the knives are held in place by wedge blocks 314 and these wedge blocks are connected to the drum by screws 315.

Fig. 26 is a vertical sectional view showing some of the control mechanism. Sheet material from a rolling mill 318 passes through a chute 319 and then over a looper unit 320 and through pinch rolls 321 and 322.

The looper unit includes a roller 323 carried at the end of arms 324 which are supported for oscillation about the axis of the roll 322. A variable torque gear motor 325 has a crank 326 connected with the arms 324 by a link 327. The motor 325 has a strong brake 328 which is applied when the current to the motor 325 is cut off, and magnetically released when current is supplied to the motor. A side elevation of the torque gear motor 325 is shown in Fig. 31.

Referring again to Fig. 26, the variable torque gear motor 325 urges the roller 323 upward toward the position indicated in dot-and-dash lines and lifts the portion of strip material 330 between the rolling mill and the pinch rolls to maintain a uniform tension in the strip as it passes from the rolling mill to the pinch rolls.

A bell crank 332 has a pivot connection 333 with the pinch roll supporting frame 334, and a roller 335 at one end of the bell crank runs on the surface of the pinch roll 321 and is held against the pinch roll by a spring 336. The upper end of the bell crank 332 carries contacts 337 and 338 on its opposite sides. These contacts are insulated from, but resiliently connected with, the bell crank by structure which will be described in the explanation of Fig. 27.

When there is no sheet material between the pinch rolls, the upper roll 321 contacts with the lower roll 322, and the bell crank 332 occupies the position shown in Fig. 26. When the bell crank 332 is in this position the contact 337 closes a circuit between separate contact members carried by a bracket on the pinch roll supporting frame. As soon as strip material enters the pinch rolls it causes the upper roll 321 to rise from the lower roll 322 by a distance equal to the thickness of the strip. This movement rocks the bell crank 332 clockwise in Fig. 26 and the small movement of the upper pinch roll is multiplied by the long lever arm of the bell crank by which the contacts 337 and 338 are carried. This movement of the bell crank causes the contact 337 to move away from its adjacent contact members, and causes the contact 338 on the other side of the bell crank to move into position to close a circuit between contact members carried by a bracket 340. Thus the bell crank 332 operates to close one circuit when there is no material in the pinch rolls and another circuit when there is material between these rolls.

Fig. 32 is a view, mostly in section, showing a gear motor 342 for driving the pinch rolls and a spring 343 pressing against bearing blocks 344, in which the upper pinch roll 321 is journaled, to maintain a pressure between the pinch rolls. This pressure is controlled by a screw 345 which threads through the pinch roll supporting frame 334 and loads the spring 343.

Referring again to Fig. 26, the strip material passes from the pinch rolls 321 and 322 to the feed rolls 60 and 61. The strip is supported between the pinch rolls and feed rolls by a chute 347 which has sides 348 which are movable toward and from one another by screws 349 (Fig. 33) to accommodate the chute for strips of different width. The screws 349 are turned by hand wheels 350.

The front and rear ends of a strip delivered from the rolling mill are always of irregular shape. Fig. 30 shows typical front and rear ends 352 and 353 of the strip 330. A device for finding the full width of the strip is located behind the pinch rolls and ahead of the feed rolls. This device for determining when the irregular front or rear edge has passed includes a luminous tube 355 (Figs. 26 and 33), such as a mercury vapor lamp, located beneath a slot in the bottom of the chute 347 and extending the full width of the chute.

Lamps 357 are carried by the sides of the chute. These lamps are slightly higher than the luminous tube 355 and directly above it when the sides of the chute are brought together to accommodate strips narrower than the full width of the chute. Opaque shields 359 connected to the sides extend under the lamps 357 and prevent light from the luminous tube 355 from shining up through the recesses in which the lamps 357 are located.

There are two finders 361 and 362 supported by a frame 363 for swinging movement above the luminous tube 355. The finders 361 and 362 are oscillated between the two extreme positions indicated by dot-and-dash lines in Fig. 23. The finder 361 has an upwardly extending arm 365. A gear motor 366 has a crank arm 367 connected with the arm 365 by a link 368. Rotation of the crank arm 367 causes the finder 361 to swing back and forth over the luminous tube 355, and the pivot connection of the arm 365 to the link 368 can set at different positions along slots in the arm and link to control the angle through which the finder 361 swings. The finder 362 is oscillated by a gear motor 371 through link connection similar to those for the finder 361.

The pivot connection between the arm 365 and the link 368 is adjusted in accordance with the width of the strip to be cut so that when the finder 361 is at one end of its angle of movement it is in line with the lamp 357 and when at the other end of its angle of movement a contact 373 touches separate contacts 374 and closes a circuit between them. A contact 375 on the finder 362 closes a circuit between contacts 377 when the finder 362 reaches the limit of its inward swing. Both of the motors 366 and 371 have magnetically operated brakes 378 which release when current is supplied to the motors 366 and 371, but stop the motors almost instantly when the power to these motors is cut off.

Figs. 28 and 29 are enlarged views of the swinging finder 361. This finder has a barrel 380, through which light from the luminous tube or lamp passes to a lens 381 which converges the light on a photo tube 382. The body of the finder, which surrounds the photo tube, is a cylinder 384 open at both ends. This cylinder turns in ball bearings 385 in a housing 386, which has slots for the lever 365 and barrel 380. The housing of the finder is closed at one end by a cover plate 387 and at the other end by a relay box 388 on which the finder is supported.

A photo electric relay unit closes a circuit when

the light from the tube 355 and lamp 357 is cut off by the strip material passing over the tube 355. The finders 361 and 362 can not swing to their extreme inner positions and close the circuits across the contact members 374 and 377 unless the strip covers the full length of the luminous tube 355 between the opaque screens 359. Therefore the closing of these circuits indicates that the irregular end has passed the luminous tube 355.

Referring again to Fig. 26, bottom guides 394 and 395 are located on the entry and delivery sides of the shear and connected to the shear frame 57 by bolts extending through slots in brackets 396 and 397 which permit limited vertical adjustment of the positions of these guides 394 and 395 with respect to the pass of the knife drums. A top guide 398 is connected to the shear frame by bolts extending through a slotted bracket 399.

A delivery table 401 has rollers 402 which are driven at a peripheral speed greater than the speed of the strip material through the shear. There is some slippage between the rollers 402 and the material resting on them before it is cut from the strip. When a predetermined length of strip has passed between the knife drums, they are brought together to shear the strip and the rollers 402 cause the severed sheet to increase its speed of travel so that it pulls away from the strip and leaves a gap of increasing width between the sheared edges.

If the knife is broken or becomes defective, so that the material is not completely sheared across its entire width, the sheet can not pull away from the strip and there is no gap as in the case of a complete cut. The presence or absence of this gap controls the knife-changing mechanism. Any time that this gap between a cut sheet of predetermined length and the strip material fails to appear when due, the mechanism automatically changes to the other set of knives.

A swinging finder 404, similar in construction to the finder shown in Figs. 28 and 29, is supported by the frame close to the upper knife drum on the delivery side of the shear. This finder 404 has an upwardly extending slotted arm 405, which has a pivot connection with a link 406.

Crank arms 407 and 408 are rigidly connected to a shaft 409 (Figs. 1 and 26) which is supported in bearing brackets 410 carried by the frame 57. The crank arm 407 has a pivot connection with the link 406, which is slotted so that the pivot connection with the crank arm can be set in different positions along the link. The crank arm 408 contacts with the surface of the knife drum 51 just beyond the ends of the knives.

When the upper knife drum 51 moves down to make a cut, the crank arms 407 and 408 turn counter-clockwise and cause the finder 404 to swing counter-clockwise into the position shown in Fig. 26. When the drum 51 moves up again after a shearing operation, the crank arms 407 and 408 turn clockwise and swing the finder 404 clockwise until a contact 412 on the finder touches separate contact members 413 and closes the circuit between them.

There are four lights under the swinging finder 404. One of these lights is a lamp 415 located under an opening in the bottom guide 395. Another lamp 416 is located above the strip material which passes through the shear and in radial alignment with the lamp 415 with respect to the swinging finder. Arcuate luminous tubes 417 and 418 on opposite sides of the lamp 416 and along

the path of the swinging finder 404 supply light to the finder at all times except when it is swinging over the lamps 415 and 416.

When the knife drum 51 is moving down to make a cut, and the finder 404 is swinging counter-clockwise, the lamp 416 is lighted and the entire path of the finder is illuminated. When the knife drum 51 is moving up after making a cut, and the finder 404 is swinging clockwise, the lamp 416 is out and the lamp 415 is lighted. If the cut is complete and the sheet severed from the strip moves faster than the strip and creates a widening gap between the severed edges as above described, then this gap permits light from the lamp 415 to reach the swinging finder which operates in such relation to the knife drums that it swings across the lamp 415 at the time when the gap is due to pass over this lamp.

When the sheet is completely severed by the shearing operation and the gap occurs as described, the finder 404 has its path illuminated during its entire clockwise movement. If a knife breaks or becomes defective so that the shearing operation does not completely sever the sheet, there will be no gap through which the light from lamp 415 can reach the swinging finder. When this occurs, no light reaches the finder during its clockwise movement over the lamps 415 and 416, and the period of darkness causes the photo tube in the finder to set the control mechanism in operation to change the relation between the knife drums and eccentrics so that other knives on the drums are used for cutting.

Fig. 27 is a detail view showing the connection of the contact 337 to the bell crank 332. The contact 337 is connected by screws to a block of insulation 420, and this block is screwed to a square plunger 421 which extends through the bifurcated upper end of the bell crank 332. A spring 422 compressed between a portion of the bell crank 332 and a shoulder of the plunger 421 urges the plunger into the position shown in Fig. 27, but permits the contact 337 to yield when it comes against the adjacent contact members carried by the pinch roll supporting frame 334. A pin 423 limits the movement of the plunger 421 to the left in Fig. 27.

Figs. 34 and 35 show the clutch mechanism for connecting gear 118 or 119 with the shaft 115. A sleeve 425 splined on the shaft 115 can be shifted from the center position shown in Fig. 34 to either the right or left to clutch gears 119 or 118, respectively, to the shaft 115. The sleeve 425 has clutch jaws 426 adjacent either end for engaging clutch jaws 427 on the hubs of the gears.

The sleeve 425 is shifted by a yoke on the end of the handle 122. The handle extends through a slot in a plate 429 and is held in set position by a square plunger 430 which has a forked end adapted to straddle the handle 122, as shown in Fig. 35, to hold the handle in neutral position. The plunger 430 is pushed back from the slot against the tension of a spring 431 when the handle 122 is to be shifted in either direction, and the plunger is permitted to move forward again over the slot and holds the handle at either end of the slot. Numerals 432 on the plate 429 indicate the correct position for the handle 122 for cutting a given length of sheet.

The clutch mechanism operated by the handle 123 for clutching the gear 120 or 121 to the shaft 115 is similar to that shown in Figs. 34 and 35.

Fig. 36 shows the reverse gear 165 between the shafts 164 and 166. The reverse gear 157 in Fig. 1 is of similar construction. A bevel gear 435

is keyed to the shaft 164, and a bevel gear 436 turns freely on the shaft 166. A sleeve 437 splined on the shaft 166 has clutch jaws 438 adjacent either end for engaging with clutch jaws on the hubs of the bevel gears. An idler 439 meshes with the gears 435 and 436. The clutch sleeve 437 is shifted by a yoke on a handle 440 which is similar to the handle 122 in Figs. 34 and 35.

The clutch jaws on the sleeve 437 engage the clutch jaws on the hubs of both gears 435 and 436 at the same time when the handle 440 is in its mid position, as shown in Fig. 36. With the parts in these positions the reverse gear is locked against movement because the idler 439 prevents the bevel gears 435 and 436 from turning in the same direction, and the clutch sleeve 437 engaging both bevel gears at the same time prevents them from turning in opposite directions.

When the reverse gear is locked it prevents rotation of the shaft 164, gear 163 (Fig. 1), and ring gear 160. Thus the handle 440 serves as a control lever for locking the ring gear 160 against rotation.

When the clutch sleeve 437 is shifted to the right in Fig. 36, power is transmitted through the gears of the reverse gear 165, and the shafts 164 and 166 turn in opposite directions. When the clutch sleeve 437 is shifted to the left in Fig. 36, power is transmitted between the shafts 164 and 166 by the clutch sleeve, and the shafts turn in the same direction.

Figs. 37-39 show the structure for holding the arm 171 in position after the idler 170 has been meshed with a selected gear of the gears 167. The handle 172 extends through an opening in a plate 442. One edge of this opening is stepped, as shown in Fig. 39, with each step the width of the gear below it, and each step so located that the handle 172 rests against the step when the idler 170 is meshed with the gear below that step. A cover plate 444 is fastened to the plate 442 by bolts 445 extending through slots in the cover plate. There are handles 446 on the nuts of these bolts so that the nuts can be loosened whenever the cover plate 444 is to be moved. One edge of the cover plate 444 has steps which cooperate with the steps on the plate 442, as shown in Figs. 38 and 39, to hold the handle 172 and arm 171 against displacement in any direction.

When the handles 446 are turned to loosen the nuts which clamp the cover plate in position, the slots through which the bolts 445 extend permit the cover plate to be shifted downward in Fig. 39 so that the stepped edges move apart and the handle 172 can be moved into any position to mesh the idler 170 with any gear on the shaft 166.

Figs. 40 and 41 are diagrams showing the variations in the velocity of the knife drums and knives. Assuming again for purposes of illustration that the knife drums have a circumference of 10 feet, then when cutting 12½ foot lengths the drums would turn 1¼ revolutions between each cut if the peripheral speed of the drums were equal to the lineal speed of the strip. Since the shear is designed to cut on multiples of a half revolution of the knife drums, the gearing must be set to cause the drums to turn 1 or 1½ revolutions while 12½ feet of strip pass through the shear. The gearing between the eccentrics and feed rolls must, of course, always be set to cause the timing eccentrics to make one revolution while the length of material to be cut passes through the feed rolls. If the gear 118 (Fig. 1) is clutched to the shaft 115 so that the drums make 1 revolution for each

revolution of the timing eccentrics, the average peripheral speed of the drums is only 80% of the lineal speed of the strip.

Curve A in Fig. 40 shows the variations in the drum speed when the drum is driven by the mechanism shown in Fig. 8 with the eccentricity set to cause the peripheral drum speed (knife speed) to equal the lineal speed of the strip as each knife reaches cutting position. The drum drive is suitable, therefore, when cutting with any knife on the drum.

If the gear 119 (Fig. 1) is clutched to the shaft 115 so that the knife drums make $1\frac{1}{2}$ revolutions for each revolution of the timing eccentrics when cutting $12\frac{1}{2}$ foot sheets, then the average peripheral speed of the knife drums is 20% greater than the lineal speed of the strip material, and the drum driving mechanism shown in Fig. 9 is used with the eccentricity of the shaft 82 set to cause the drum speed to vary in accordance with curve C of Fig. 41. The peripheral drum speed (knife speed) equals the lineal speed of the strip four times during a revolution of the knife drum, and each of the four times is an instant when one of the knives is in cutting position.

When cutting sheets $11\frac{1}{4}$ feet long, the gear 118 (Fig. 1) is clutched to the shaft 115 so that the knife drums make 1 revolution while $11\frac{1}{4}$ feet of strip material pass through the shear and the timing eccentrics make one revolution. The average peripheral drum speed is 89% of the lineal strip speed, and one-half of the eccentricity required to give the curve A in Fig. 40 can be used to cause variations, according to the curve B, which make the peripheral drum speed equal to the lineal strip speed at the time each knife is in cutting position so that no matter which knife is used for cutting it is moving at the same speed as the strip while making the cut.

Curve D in Fig. 41 shows variations in the drum speed when driving the drum with the mechanism shown in Fig. 9 and with the eccentricity set to obtain correct knife speed when cutting sheets $13\frac{3}{4}$ feet long. The knife drums make $1\frac{1}{2}$ revolutions for each revolution of the timing eccentrics.

Fig. 42 shows the control mechanism of the shear and the electrical connections. The relays and contactors are magnetically operated, and those described as normally open or normally closed are open or closed respectively when there is no power supplied to their operating magnets.

The relays and contactors are of conventional design and have the characteristics listed below.

Relay	Normal position	Characteristics
R. 1.....	Open.....	Time delay closing.
R. 2.....	Open.....	
R. 4.....	Closed.....	Adjustable time delay closing.
R. 5.....	Open.....	Time delay closing.
R. 6.....	Open.....	Time delay opening and closing.
R. 7.....	Closed.....	Time delay opening and closing.
R. 8.....	Open.....	Time delay opening.
R. 9.....	Closed.....	
R. 10.....	Open.....	Time delay opening.
R. 10A.....	Open.....	Time delay opening.
R. 11.....	Open.....	Time delay opening. Adjustable time delay.
R. 12.....	Open.....	Time delay opening.
R. 13.....	Open.....	Time delay opening.
R. 14.....	Open.....	Adjustable time delay. Time delay opening.
R. 15.....	Open.....	
R. 16.....	Closed.....	
R. 17.....	Open.....	
R. 18.....	Closed.....	Manually closed or reset. Opened electrically and stays open.
R. 19.....	Open.....	Adjustable time delay. Time delay closing.
R. 20.....	Closed.....	Time delay opening.

Contactors	Normal position	Characteristics
C.1.....	Open.....	Differential. Adjustable time delay closing.
C.3.....	Open.....	
C.4.....	Open.....	
C.5.....	Open.....	
C.6.....	Open.....	
C.7.....	Open.....	Time delay closing.
C.8.....	(Manually opened. Stays open until electrically closed and then remains closed.)	
C.9.....	(Manually closed. Stays closed until electrically opened and then remains open.)	
C.10.....	Open.....	Time delay closing.
C.11.....	Closed.....	
C.12.....	Closed.....	
C.13.....	Open.....	

After the shear has been set to cut sheets of a desired length, the operator closes power line switches S1, S2, S3 and S4, opens switches S5 and S6, and closes switches S7 and S8. He then presses the start button at push-button station PB9, which supplies control current to relays R1 and R2.

Relay R1 is a normally open, time delay closing relay, and when it closes current is supplied to the operating magnet of a normally open contactor C1 which controls the supply of power to the control panel P1.

Relay R2 is normally open, and when closed completes the circuit from switch S3 to contactor C4, to one of the contacts 413, to one terminal of open switch S6, to one terminal of a relay R13, to one terminal of relays R14 and R19, to one terminal of push-button stations PB5 and PB6, to one terminal of photo cell relay PCR3, to one terminal of push-button station PB2, to one terminal of relay R8, to one terminal of relay R15, through closed relay R16 and through closed contacts V, and closed relay R9 to the magnet of a normally open contactor C5, to one terminal of a relay R17, and to one terminal of a push-button station PB1.

Control current is also supplied to one terminal of photo cell relay PCR1, to one of the contacts 374 and 377, and to one terminal of left-hand relay R10, also to one terminal of photo cell relay PCR2 and one terminal of push-button station PB3. Control current also flows to one terminal of push-button station PB7, to one terminal of push-button station PB8, to one terminal of push-button station PB4, then to upper contact G' and lower contact F, then to coil of relay R5, closing it, then through closed switch S8, through normally closed relay R7 to a contact at limit switch LS1 and one terminal of relay R10A.

After the control current has been distributed as described, relay R1 closes, which closes contactor C1, sending power current to motor 67 through a series of accelerating steps and speed controlling and adjusting devices, all or any of which may be controlled through the control current relayed through relay 1. The motor 67 accelerates until it reaches a predetermined speed. The closing of contactor C4 establishes a circuit to one terminal of contactors C7, C7' and C6, also to one terminal of contactor C3, also through closed contactors C12 to control panel P2 upon which are mounted the conventional starting, speed regulating and controlling devices necessary for the operation of the variable speed pinch roll gear motor 342.

The closing of switch S2 carries alternating current power to one terminal of contactor C13.

Just as soon as motor 67 starts, limit switch LSI starts revolving, and when the commutator bar 450 in the adjustably mounted drum 451 reaches the contacts of the limit switch, a circuit is closed to coil of relay R10A. The relay closes and supplies current to contactor C6, relay R8, and contactor C3, closing them, sending power current to the solenoids which apply brake 243 and release the brake from drum 245, causing differential unit 116 to revolve and shaft 110 to come to rest holding the knife drums in open non-shearing position. Switch S1 closes the circuit for alternating current from the main supply line to luminous tube 418 and lamp 415, one terminal of relay R12 to luminous tube 417 also to the knife changing photo cell units, to the full-width finding photo cell units, to contact G', then through relay R5 to lamps 357, then to luminous tube 355. Light current is also carried to contact F' and to one terminal of open relay R6.

When strip material enters between pinch rolls 321 and 322, bell crank 332 is moved clockwise, breaking the circuit between contacts G and G' and closing a circuit between contacts F and F'. Breaking the circuit between contacts G and G' opens relay R5, turning off lamp 357 so that photo cell relays PCR1 and PCR2 close and relay currents to close contactors C1 and C1'. The closing of the contactors C1 and C1' supplies current to control panels P3 and P4 upon which are mounted the necessary conventional starting, speed regulating, and controlling devices for the variable speed gear motors 366 and 371. These motors are coupled to the swinging finders and cause them to swing towards each other until the contacts 373 and 375, carried by the finders, touch the contacts 374 and 377 and supply current to coils of relays R10, closing them, and causing control current to flow to one coil of differential contactor C6, opening it, and cutting off the supply of power to the solenoid which releases the brake from drum 245. Current to the solenoid applying brake 243 still flows through contactor C3, this contactor being held closed by time delayed opening relay R8. As soon as the latch drops into the recess in brake drum 245, contacts V open in the same way as the contacts 273 and 275 in Fig. 13, opening relay R9 which causes contactor C5 to open, and cuts off current from solenoid of brake 243 and releases the brake. The dropping of the latch into brake drum 245 releases the toggle mechanism and applies the brake to drum 245, so that brake 243 is released simultaneously with the application of the brake to drum 245, bringing the differential unit 116 to rest, and rotating shaft 110. The latch drops into the nearest recessed latch block in brake 245, so that the eccentrics are brought into time with the nearest knife.

In the event the front end of the material is irregular in shape, as illustrated in Fig. 30, the swinging finders continue to move only as long as relays PCR1 and PCR2 remain closed. If in the course of the travel of either of the finders it is able to pick up light from the luminous tube 355, the relay PCR1 or PCR2 opens and remains open until the strip material covers the luminous tube 355 and causes relays PCR1 or PCR2 to close, so that the contactors C1 or C1' again close and start motors 366 and 371 and the swinging finders moving again. Thus the finders do not swing over the width of the strip until the irregular front end has passed the luminous tube 355.

The throwing over of bell crank 332 to close

the circuit between contacts F and F' supplies control current to coil of relay R6, which after a predetermined delay closes and relays current to lamps 357, turning them on so that when the swinging finders return to their original position they will pick up light from these lamps 357 which will open relays PCR1 and PCR2 and cause contactors C1 and C1' to open, cut off current from motors 366 and 371, apply their brakes, and bring them to rest.

The throwing over of bell crank 332 to close the circuit between contacts F and F' relays current from contact F to contactor C13, closing it and sending alternating current power to torque-adjusting control panel P5 and then to the variable torque gear motor 325 and brake 328 to release the brake and operate the torque motor to raise the arms 324 and roller 323.

The shear cuts the material to the desired lengths, and after each cut the delivery table conveys the sheared material away at a faster speed than the material is fed into the shear, so that a gap occurs between the rear end of the sheared material and the front end of the material being fed through the shear. This gap enables the swinging finder 404 to receive light from lamp 415 when the finder passes over the gap between luminous tubes 417 and 418 so that an uninterrupted supply of light strikes the photo cell tube, during the whole travel outward of the swinging finder. When the contact 412 on the finder closes a circuit between the separate contact members 413, current flows to coil of relay R11, closes it, and causes current to flow to coil of relay R12, closing it and turning on lamp 416 which allows the swinging finder to receive an interrupted supply of light during its return travel, when the strip material, feeding through the shear, has blocked off light from the lamp 415. Failure of the photo cell tube to receive light at this time would cause it to operate the knife changing mechanism when not required.

In the event that the knives fail to shear the material across its full width, and the swinging finder fails to receive light from the lamp 415, as fully explained in the description of Fig. 26, the relay PCR3 closes, and relays current to coil of relay R14, closing it, relaying current to close contactor C6, also relaying current to close relay R8 which sends current to contactor C3, closing it, so that current flows to brake 243 and applies this brake, and flows to the solenoid which releases the brake from drum 245. Upon the closing of relay PCR3 current is also relayed to coil of relay R13, closing it, which in turn relays current to contactor C8, closing it, sending current to brake solenoid 271 which releases the brake from brake drum 246, also sending current through closed contactor C9 to solenoid 292 (Fig. 19), withdrawing locking fork 290, and allowing latching pin 296 to drop down in front of the collar 298 on locking fork 290, which holds the locking fork in retracted position, also relays current to coils of relays R17 and R15, closing them, sending current through contacts 273 and 275 (Fig. 13), and opens relay R16 and R9, transferring the control of contactor C5 to the brake mechanism for drum 246, instead of the brake mechanism for drum 245.

Current is also relayed through closed relay R18 to contactor C10, closing it, allowing power current to flow to solenoid 300 (Fig. 19), which raises the latching pin and allows the locking fork to slide behind the collar on the plunger of brake mechanism for drum 245 corresponding to

the plunger 270 of Figs. 13 and 19. The locking fork holds the brake released and prevents the latch from dropping into the recesses in the brake drum 245. Thus it will be seen that the control of the brake 243 is transferred to the brake mechanism for drum 246, and this drum, which has adjustably positioned recess blocks 249 into which the latch 280 enters, controls the relation between the eccentrics, driving arms, and knife drums, when the differential unit 116 comes to rest.

The closing of contactors C6 and C3 sends power currents to brake 243, applying it, and to the solenoids which release the brakes from drums 245 and 246. Up to this time the brake has been held off drum 246 by locking fork 290, the current flowing to the solenoid 271 further releases this brake and makes the removal of locking fork 290 (Fig. 19) easier for solenoid 292 by removing all unnecessary friction.

After a predetermined delay, relay R14 opens and cuts off the supply of control current to the closing magnet of contactor C6. Relay R19 closes, relaying current to the opening magnet of contactor C6, opening it and cutting off the supply of current to the solenoid 271 so that latch 280 is released and drops into the nearest convenient recess in the brake drum 246.

As soon as the latch drops into the recess in the brake drum 246, contacts 273 and 275 open and stop the flow of control current to contactor C5, cutting off the power current to brake 243, and releasing it, and bringing the eccentrics into time with the spare set of knives on the knife drums.

To prevent the damaged knives from coming into use again, current is furnished through push-button station PB1, which opens relay R18 and contactor C9, both of which when opened will be mechanically held in the open position until such time as the damaged knives are replaced, after which relay R18 and contactor C9 can be manually reset or closed again.

Contactors C8, which is closed when changing knives, is held closed and it is necessary to manually open or reset this contactor after replacing the damaged knives. The contactor C9, which is opened by operating push-button station PB1, and held open, is reset or closed after replacing the damaged knives.

When the shear is set up to cut the shortest length within its range, switches S1, S2, S3, S4, S5 and S6 are closed, switches S7 and S8 are opened. The shear comes up to speed, as previously explained, and the knife drums are thrown into non-shearing, open position when the contact 412 on the swinging finder 404 touches the separate contact members 413 and closes a circuit for control current to the coil of relay R11, closing it and sending control current through closed switch S6 to a contact on limit switch LS1, where current flows through the commutator bar 450 to the coil of relay R10A, closing it, relaying current to the closing magnet of contactor C6, closing it, and to relay R8 closing it, and relaying current to contactor C3 closing it, and sending power current to the solenoid which releases the brake from drum 245, and to the solenoid which applies brake 243 so that the knife drums are held in non-shearing position as previously described.

When strip material enters between the pinch rolls 321 and 322, the irregular front end passes the luminous tube 355, as previously explained, the full width finding mechanism throws the

knife drums into shearing position, makes the front end cut, and the contact 412 on swinging finder 404 touches the contact members 413 and causes the knife drums to be moved again into non-shearing position, as previously described. If it is then desirable or necessary to divide the strip material, this is accomplished by operating push-button station PB3, which relays current to the opening magnet of contactor C6, opening this contactor and causing the knife drums to be moved into shearing position without using the photo cell units.

After the cut is made, the knife drums are again thrown into open non-shearing position, as previously explained.

When the end of the strip material passes out of the pinch rolls 321 and 322, the bell crank 332 moves back to its original position and closes the circuit between contacts G and G', so that control current flows through closed switch S5 to closed relay R20 and opens it after a predetermined time delay. Before opening, the relay R20 allows current to flow to the opening magnet of the contactor C6. The contactor C6 opens and cuts off the power supply to brake 243 and the solenoid which releases the brake from drum 245 so that the knife drums move into shearing position and make the rear end cut on the strip material. After making this cut the knife drums are again thrown into open non-shearing position and held thus until more strip material comes from the mill.

To prevent swinging finder 404 from throwing the shear knife drums into non-shearing position, when contacts 412 touch contacts 413, before making another cut on the strip material, in the event that it was necessary to change knives, by closing the circuit between contacts 413 and relaying control current through closed switch S6 to limit switch LS1, photo cell relay PCR3 relays current to coil of relay R4, opening it and holding it open for a predetermined interval.

Figs. 43 and 44 show the drum 451 which carries the commutator bar 450. The drum has an inside web 452 which is held against a flange 453 by a screw 454 which extends through an arcuate slot in the web 452 and threads into the flange 453. When the screw is loosened, the drum can be turned through an angle, limited by the length of the arcuate slot, to change the angular position of the commutator bar 450 with respect to the shaft 108. Such a change in the position of the commutator bar in one direction or the other causes the brakes to be applied earlier or later when changing knives or when throwing the drums into non-shearing position.

The operation of the shear has been described in the explanation of Fig. 42. The manner of setting up the shear to cut a given length will be described briefly, using the gear ratios of the mechanism illustrated in Fig. 1.

When knives 1 and 3 are to be used for cutting, the drums are moved into the position in which knife 1 or 3, and the eccentrics, are in shearing position. The gears 53 and 54 of the knife drums and the eccentric shaft 106 are marked to indicate to an operator, standing on one side of the shear, when the knives and eccentrics are in shearing position exactly.

The coupling units 81 and 87 are operated to move the driving arms away from the driving lugs in the knife drums. The eccentricity of the shafts 76 and 82 is then set by turning the hand-wheel 200. The correct setting for the shafts 76 and 82 is obtained from a chart, and their posi-

tion is indicated on the scale 202 (Fig. 2) by the pointer 201. The coupling units 81 and 87 are then operated to bring the driving arms on the shafts 76 and 82 into contact again with the driving lugs on the inside of the knife drums.

If the shear is to cut a sheet 13 feet 3½ inches in length, and the circumference of the knife drums is 10 feet, the gear 119 is clutched to the shaft 115 so that the eccentrics are driven through the gears 126 and 119, and the timing eccentrics make one revolution while the knife drums make 1½ revolutions. This choice of gears is made because 1½ revolutions of the knife drums is the multiple of ½ revolution, which gives a knife speed closest to the strip speed, each knife moving 15 feet while 13 feet 3½ inches of strip pass through the shear. The eccentricity of the shafts 76 and 82 causes the knife drums to slow down so that their peripheral speed (knife speed) is equal to the lineal strip speed at the moment of shearing.

The circumference of the feed rolls 60 and 61 is 5 feet, and when the ring gear 145 is stationary the feed rolls turn twice as fast as the knife drums and feed 10 feet of strip material through the shear for every revolution of the knife drums. In order to cut 13 feet 3½ inches sheets it is necessary to decrease the feed roll speed in proportion to the drum speed, so that 20½ inches less material is fed through the shear for each cutting operation than would be fed with the feed rolls running at twice the knife drum speed. This 20½ inches is the difference between 15 feet of strip, corresponding to 1½ revolutions of the knife drums, and 13 feet 3½ inches, which is the length to be cut.

The ring gear 145 must, therefore, be rotated in the direction which subtracts from the speed of the shaft 135. The direction of rotation of the ring gear 145 is controlled by the reverse gear 157.

When the gear 176 is clutched to the shaft 174, the largest of the gears 162 is effective to add or subtract 2 inches from the speed of the feed rolls, and each successive gear is effective to add or subtract 2 inches more than the next larger gear. By meshing the idler 175 with the tenth gear from the left, 20 inches can be subtracted from the speed of the feed rolls. When the gear 177 is clutched to the shaft 174, the gears of the set 162 differ by increments of 1 inch instead of 2.

When motion is transmitted through the gears 167 and reverse gear 165 to the ring gear 160 of the differential unit 159, the movement of this ring gear adds to or subtracts from, depending on the direction of rotation, the speed of the shaft 156. When the idler 170 is meshed with the largest of the gears 167, the ring gear 160 is rotated at such speed that it adds or subtracts one-eighth inch from the speed of the feed rolls, and each successive gear of the set is effective to add or subtract one-eighth inch more than the next larger gear.

The setting of the gears to subtract 20 inches from the speed of the feed rolls is described above. In order to subtract the additional ½ inch when cutting sheets 13 feet 3½ inches in length, the idler 170 is meshed with the fourth largest gear of the gears 167.

The combination of driving devices by which the ring gear 145 can be rotated forward or reverse, so as to either add to or subtract from the speed of the feed rolls, has the important advantage of reducing by half the amount of

speed correction which must be obtained from these driving devices. If the correct speed can not be obtained by adding to the nearest speed below the correct value, it can be reached by subtracting from the next step of speed, which is above the correct value.

The motor 67 is run at the speed which drives the feed rolls 60 and 61 with a peripheral speed equal to the delivery speed of the rolling mill.

The drum and feed roll circumferences, and the gear ratios given in this specification, are illustrative and the invention can be embodied in a shear having drums and rolls of various sizes and other gear ratios. Other changes and modifications may be made in the shear illustrated, and various features of the invention may be used alone or in combination with other features without departing from the invention defined in the claims.

I claim:

1. A rotary shear comprising two knife-carriers with means for rotating them in opposite directions at the same speed, four knives on each carrier at equal angular distances around the carrier, mechanism operable to move at least one of the carriers toward the other to bring the carriers together to shear material passing between them, means for causing said mechanism to operate at given multiples of ½ revolution of the knife-carriers, and control means for causing the operation of said mechanism to correspond with the arrival of either the odd or even numbered knives at shearing position.

2. Rotary shearing apparatus including two carriers, each of which carries a plurality of angularly-spaced knives, means for rotating the carriers, and mechanism for producing relative movement of the knife-carriers to bring them closer together to cause the knives to shear material passing between the carriers when the odd or even numbered knives on the carriers are in position for shearing, and means for determining which set of knives will be in shearing position when said mechanism causes relative movement of the carriers for a shearing operation.

3. A rotary shear including two carriers between which material passes, a plurality of knives angularly spaced around each carrier, means for rotating the carriers and mechanism for moving at least one of the carriers toward and from the other while rotating, said mechanism including timing means for causing the knife-carriers to be brought together when a particular knife or knives are in position to shear the material between the carriers, and means, operable while the shear is running for changing the relation of the timing means to the carriers to cause them to be brought together when other knives are in position to shear the material.

4. A rotary shear including two knife-carriers between which material passes, a plurality of knives angularly spaced on each carrier, means for rotating the knife-carriers and mechanism for moving at least one of the knife-carriers toward and from the other while rotating, said mechanism including timing means for causing relative movement of the carriers toward one another when a particular knife or knives are in position to shear the material between the carriers, and control apparatus including means operable while the shear is running for changing the relation of the timing means to the knife-carriers to prevent said knife or knives from

being in shearing position when the carriers are brought together and to cause another knife or knives to be in such position when the carriers are brought together for a shearing operation.

5 5. The combination with shearing apparatus including two rotary knife carriers between which material passes, means for rotating the knife carriers, and mechanism for moving at least one of the carriers toward the other when the knives
10 are in shearing position, of means, operable while the shear is running, for moving one knife into the cutting position of one which becomes broken or defective and moving said defective one out of said cutting position.

15 6. In a rotary shear of the type having two rotary knife carriers between which material passes, knives on said carriers, and mechanism for rotating the carriers and for producing relative movement of the knife carriers to bring them
20 together when the knives are in position for shearing the material passing between the carriers, of automatic means by which a broken or defective knife is moved out of cutting position and another knife moved to said position if the
25 shear fails to completely sever the material during a shearing operation.

7. The combination with shearing apparatus including two rotary knife carriers between which material passes, means for rotating the
30 knife carriers, and cam mechanism for producing relative movement of the carriers toward one another when the knives are in shearing position, of means operable while the shear is running, for changing the relative positions of the cam mechanism and carriers to move a new knife into the
35 cutting position of one which becomes broken or defective and to move said defective one out of said cutting position.

8. A flying shear including knife carriers,
40 means for rotating the carriers, and mechanism for moving the carriers toward and from one another to bring the knives together to shear material passing between the carriers, said mechanism including cam means for moving each
45 carrier, and other cam means for moving the first-mentioned cam means in timed relation to the revolutions of the knife carriers.

9. A flying shear including knife-carriers, means for rotating the knife-carriers, and mechanism for moving at least one of the knife-carriers toward and from the other to shear material passing between the carriers, said mechanism including two cam means with different
50 cycles of operation, and motion-transmitting means for imparting the displacement of both cam means to one of said knife-carriers.

10. A flying shear including rotary knife-carriers and mechanism for producing relative movement of the knife-carriers toward and from one another to shear material passing between them, said mechanism including two cams, means for rotating the cams at different speeds, and connections through which both of said cams co-
60 operate to produce the relative movement of the knife-carriers toward and from one another.

11. A flying shear including rotary knife-carriers and mechanism for moving at least one of the carriers toward and from the other to shear material passing between the knife-carriers, said mechanism comprising two cams, means for rotating the cams with the speed of one cam twice as great as the speed of the other, and means which are displaced by said cams including a motion-transmitting member operated
70 75

by both of the cams and operatably connected with one of the knife-carriers.

12. A flying shear including knife carriers, means for rotating the carriers, and mechanism for moving the carriers toward and from one another to bring the knives together to shear material passing between the carriers, said mechanism including cam means for moving one knife carrier up, other cam means for moving the other knife carrier down at the same time that the first knife carrier is moving up so that the weight of each knife carrier balances the other and reduces the power necessary to drive the cam means, and separate driving means for each of said cam means.

13. A flying shear including knife carriers, means for rotating the carriers, and mechanism for moving the carriers toward and from one another to bring the knives together to shear material passing between the carriers, said mechanism including separate cam means for each carrier, a common shaft and separate motion transmitting means between the shaft and each of said cam means for driving the cam means in such relation that one of said cam means causes its knife carrier to move up at the same time that the other cam means causes its knife carrier to move down so that the weight of one knife carrier assists the rotation of the shaft during the time that the weight of the other knife drum opposes the rotation of the shaft.

14. A rotary shear comprising an upper and a lower knife carrier between which the material passes, mechanism for moving the knife carriers toward and from one another including slides for moving the upper knife carrier, other slides for moving the lower knife carrier, cam means for moving the upper carrier slides, other cam means for moving the lower carrier slides, separate bearings for the respective cam means, and timing cams for moving said bearings to increase the velocity of the motion imparted to the knife carriers by said cam means as the carriers are moved for a shearing operation.

15. In a flying shear having knife carriers and means for rotating the carriers, mechanism for moving at least one of the carriers toward and from one another in timed relation with their rotation so that the knives on the carriers are brought together when in shearing position, and means operable while the carriers are rotating for preventing operation of said mechanism which causes the relative movement of the knife-carriers toward and from one another, including means for automatically putting said mechanism in timed relation with the carriers when said mechanism is set in operation while the carriers are rotating.

16. In a flying shear having knife carriers, and mechanism for producing relative movement of the knife carriers toward and from one another, means for rotating the knife carriers including a driving shaft extending through one of the carriers and supported by bearings which move with that carrier toward and from the other carrier, means on the shaft for driving the carrier through which said shaft extends, and means for moving said bearings to shift the axis of the shaft with respect to the carrier axis to regulate the variation in the rotary speed of the carrier.

17. In a flying shear having knife drums, means for rotating the knife drums including a driving shaft extending through a drum, motion transmitting means between the driving shaft

and the drum constructed and arranged to drive the drum at varying speed relative to the speed of the driving means, and meshing gears connected to the knife drums to prevent said drums from getting out of rotational timed relation.

18. A rotary shear comprising knife drums with mechanism for moving them toward and from one another to shear material which passes between said drums, and means for rotating the knife drums with a peripheral speed which is equal to the lineal speed of the material at the time of shearing, said means including a shaft extending through one of the knife drums, a lug on the inside of the drum, a driving arm on the shaft for contacting with said lug to transmit rotary movement from the shaft to the drum, and means for shifting the axis of said shaft with respect to the drum axis to produce a variable speed of rotation of the drum.

19. A rotary shear comprising knife carriers with mechanism for producing relative movement of said carriers toward and from one another to shear material which passes between them, and means for rotating the knife carriers with a peripheral speed which is equal to the lineal speed of the material at the time of shearing, said means including a shaft extending through one of the knife carriers, a lug on the inside of the carrier, a driving arm on the shaft for contacting with said lug to transmit rotary movement from the shaft to the carrier, means for shifting the axis of said shaft with respect to the axis of rotation of the knife carrier to produce a variable speed of rotation of the carrier, and shock-absorber means to prevent violent impact of the arm and lug.

20. In a rotary shear having knife drums, each of which carries a plurality of knives, driving means for a knife drum including a shaft extending through the drum, means for shifting the shaft with respect to the drum axis, driving arms on the shaft, two sets of lugs on the inside of the drum, one set of said lugs being so constructed and arranged that the drive transmitted through those lugs from the shaft to the drum when their axes are eccentric produces a drum speed at the time of shearing which is faster than the average speed of a complete revolution, the other set of lugs being so constructed and arranged that the drive through them obtains a speed, at the time of shearing, which is less than the average drum speed, and means for moving said driving arms into position to drive the drum through either set of lugs.

21. In a rotary shear having knife carriers, each of which carries a plurality of knives, driving means for a knife carrier including a shaft extending through the carrier, means for shifting the shaft with respect to the carrier axis, two sets of driving arms on the shaft, lugs on the inside of the carrier for transmitting driving power from the arms to the carrier, and means for moving either set of driving arms into operative relation with the lugs, one set of driving arms being so constructed and arranged with respect to the lugs that the drive transmitted through those arms from the shaft to the carrier when their axes are eccentric produces a carrier speed at the time of shearing which is faster than the average speed of a complete revolution, the other set of driving arms being so constructed and arranged with respect to the lugs that the drive through them obtains a speed, at the time of shearing, which is less than the average carrier speed for a complete revolution of the carrier.

22. In a rotary shear having knife carriers, each of which carries a plurality of knives, driving means for a knife carrier including a shaft extending through the carrier, means for shifting the shaft with respect to the carrier axis, two sets of driving arms on the shaft, two sets of lugs on the inside of the carrier, one set for each set of driving arms, means for axially shifting the relative positions of the arms and lugs to cause one set of arms to drive the carrier through one set of lugs or to cause the other set of driving arms to drive the carrier through the other set of lugs, one set of lugs being so constructed and arranged that the drive transmitted through those lugs from the shaft to the carrier when their axes are eccentric produces a carrier speed at the time of shearing which is faster than the average speed of a complete revolution, the other set of lugs being so constructed and arranged that the drive through them obtains a speed, at the time of shearing, which is less than the average carrier speed, and means for moving said driving arms into position to drive the carrier through either set of lugs.

23. In a flying shear, the combination with knife drums and mechanism for moving them toward and from one another, of drum driving means for rotating the drums with constant speed, or variable speed which brings the peripheral speed of the drums to the lineal speed of the strip at the time of shearing, said drum driving means including a shaft extending through the drum and shiftable to move its axis into and out of coincidence with the drum axis, driving members connected with the shaft, and lugs on the inside of the drum having cam faces with which the driving members contact.

24. The combination with a flying shear having knife-carriers and mechanism for moving at least one of the knife-carriers toward the other to shear material between them, of means for stopping the operation of said mechanism independently of the operation of the knife-carriers, means for feeding material between the knife-carriers, and devices for starting the operation of said mechanism including means for detecting the passage of the full width of the material when material having an irregular end is moved toward shearing position by the feeding means.

25. Rotary shearing apparatus comprising knife carriers, feed means for moving material between the knife carriers, mechanism for moving producing relative movement of the knife carriers to shear the material, and control means for said mechanism including a light-sensitive device and means for moving it transversely of the material passing through the feed means.

26. The combination with a flying shear having knife-carriers and mechanism for moving at least one of the knife-carriers toward the other to shear material between them, of means for feeding material between the knife-carriers, and devices for controlling the operation of said mechanism including two light-sensitive means, each enclosed in an opaque housing having a barrel opening through the wall of the housing for the admission of light to the light-sensitive means, mechanism controlled by the light-sensitive means in each housing for swinging the barrel of that housing through an angle subtended by one-half the width of the material, and in a direction transverse of the direction of movement of the material through the feed means, a source of light extending under the material for its entire width and extending along a line

to supply light to one or the other of said light-sensitive means, during the swinging movement of its barrel, unless the source of light is completely covered by the material.

27. The combination with a flying shear, of mechanism for causing a new knife to cut the material if the operating knife becomes broken or defective, and control means including a device for detecting a defective cut which fails to completely sever the material across its entire width.

28. The combination with a flying shear having knife-carriers, of mechanism for causing a new knife to cut the material if the operating knife becomes broken or defective, and means for detecting a defective cut which fails to completely sever the material across its entire width including illuminating means in position to be passed over by the metal after it has passed between the knife carriers, and light sensitive means above the illuminating means and on the other side of the metal from the illuminating means.

29. Rotary shearing apparatus comprising two knife carriers, a motor operatively connected with the knife carriers for rotating them simultaneously in opposite directions, mechanism for producing relative movement of the knife carriers toward and from one another to shear material passing between them, and driving connections between said mechanism and said motor, including means for disconnecting said mechanism from the driving motor so that said mechanism can be held stationary while the knife carriers rotate, and means for again connecting said mechanism with the motor in timed relation with the knife carriers while the motor and knife carriers are rotating.

30. A flying shear comprising knife-carriers, means for rotating the knife-carriers, mechanism for producing relative movement of the rotating knife-carriers toward and from one another to shear material passing between them, a motor, driving connections between the motor and said mechanism, and apparatus for making the driving connections ineffective to operate said mechanism while the knife-carriers continue to rotate, said apparatus including means for causing said mechanism to stop when the knife-carriers are out of shearing position.

31. In a flying shear having rotary knife-carriers and mechanism for moving at least one of the knife-carriers toward and from the other to bring said carriers together and shear material passing between them, power driving means for said mechanism, apparatus for disconnecting the power from said mechanism while the knife-carriers are rotating, and means for preventing said mechanism from stopping with the knife-carriers close together.

32. In a flying shear having rotary knife-carriers and mechanism for moving at least one of the knife-carriers toward and from the other to bring said carriers together and shear material passing between them, means for causing said mechanism to stop while the knife-carriers continue to rotate, and automatic control apparatus for determining the part of the cycle of operation of said mechanism at which the stopping means becomes effective.

33. Rotary shearing apparatus comprising two knife carriers, a motor operatively connected with the knife carriers for rotating them simultaneously in opposite directions, feed rolls for moving the material through the apparatus and

between the knife carriers, driving mechanism for rotating the feed rolls in set relation to the speed of the knife carriers, and mechanism for synchronizing the speed of the feed rolls with that of the strip material, said mechanism including other driving means operable to either add or subtract a selection of definite values to the rotary speed imparted to the feed rolls by said driving mechanism.

34. Rotary shearing apparatus comprising two knife carriers, each of which has a plurality of knives at equal angular distances from one another, a motor operatively connected with the knife carriers for rotating them simultaneously in opposite directions, means for producing relative movement of the knife carriers toward one another to shear material between them, control means for determining which particular knife or knives are in position to shear when the carriers are moved together, feed rolls for moving the material through the apparatus and between the knife carriers, driving mechanism for rotating the feed rolls in set relation to the speed of the knife carriers, and other driving means operable to either add or subtract a selection of definite values to the rotary speed imparted to the feed rolls by said driving mechanism.

35. Shearing apparatus comprising two knife carriers and means for rotating them, feed rolls for moving material between the knife carriers, mechanism for causing relative movement of the knife carriers toward and from one another to shear the material between them, driving means for operating said mechanism and the feed rolls in timed relation with each other so that a definite length of material is fed between the rolls for each shearing operation, said driving means including devices for changing said length of material in steps of equal value to cut a multitude of different lengths.

36. In a flying shear comprising two knife-carriers and means for rotating them, feed rolls for moving material between the knife-carriers, mechanism for producing relative movement of the knife-carriers toward and from one another to shear the material between them, driving means for operating the feed rolls and said mechanism in timed relation with each other so that a definite length of material is fed between the knife-carriers during the interval between shearing operations, said driving means including apparatus for changing the relative speeds of said mechanism and the feed rolls to any of a multitude of ratios to cut the material in different lengths.

37. Rotary shearing apparatus including two knife carriers and means for rotating them, rolls for feeding material between the knife carriers, mechanism for moving at least one of the knife carriers toward the other to shear the material between them, means operable with the carrier rotating to prevent operation of said mechanism, and automatic control means responsive to the passage of the front end of a piece of material for causing said mechanism to bring the carriers together to shear the material immediately after the front end of material has passed between the knife carriers.

38. Rotary shearing apparatus including two knife carriers and means for rotating them, rolls for feeding material between the knife carriers, mechanism for moving at least one of the carriers toward the other to shear the material between them, means operable with the carriers rotating to prevent operation of said mechanism,

means for detecting the passage of the full width of material at the front end of a strip, and automatic control means responsive to the detecting means for causing said mechanism to operate immediately after the front end of material has passed between the knife carriers.

39. Shearing apparatus comprising two knife carriers and means for rotating them, feed rolls for moving material between the knife carriers, mechanism for causing at least one of the knife carriers to move toward and from the other to shear the material between them, driving means for rotating the feed rolls and said mechanism in timed relation with each other so that a definite length of material is fed between the knife carriers for each shearing operation, and automatic control means for operating said mechanism to shear the material immediately ahead of its rearward end.

40. A flying shear including knife carriers and knives carried thereby, means for rotating the carriers, and mechanism for producing relative movement of the carriers toward and from one another to bring the knives together to shear material passing between the carriers, and automatic control means operable upon failure of the knives to completely sever the material for bringing new knives into the position of those which made the defective cut.

41. In a flying shear, the combination of rotary knife carriers having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers, while the shear is running.

42. In a flying shear, the combination of rotary knife carriers having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers, while the shear is running, driving means running at predetermined, constant speed, driving arm means cooperating with said driving means to drive said knife drums at the same speed, or at a predetermined, higher or lower speed, at a predetermined time, than the speed of said driving means, together with means for controlling the amount that said knife carriers rotate at said predetermined, higher or lower speed than said driving means, together with means whereby the centers of said driving means and driving arm means maintain a constant, predetermined position with relation to the centers of said knife carriers, while said knife carriers are moving into, or out of, shearing position.

43. In a flying shear, the combination of rotary knife carriers having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers,

while the shear is running, said means including a swinging finder and a predetermined arrangement of controlling lights cooperating with photo-electric relay means.

44. In a flying shear, the combination of rotary knife carriers, having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers, while the shear is running, means for driving said knife carriers at a predetermined speed, together with controlling means whereby the speed of said knife carriers may be kept the same, or changed, at a predetermined time, to a speed higher or lower than said predetermined speed, together with means for moving said knife carriers into, or out of, shearing position, together with means for throwing said knife carriers out of shearing position, when said knife carriers are in a predetermined position, together with means including a swinging finder and a predetermined arrangement of controlling lights, cooperating with a photo-electric relay for throwing the said knife carriers back into shearing position with the nearest conveniently located pair of knives, together with means for setting the shear to shear any one of numerous predetermined lengths which differ by equal increments.

45. In a flying shear, the combination of rotary knife carriers, having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers, while the shear is running, together with means for moving said knife carriers into, and out of, shearing position, together with means for throwing said knife carriers out of shearing position, when said knife carriers are in a predetermined position, together with means, including a swinging finder and a predetermined arrangement of controlling lights, co-operating with a photo-electric relay for throwing said knife carriers into shearing position, and then out of shearing position.

46. In a flying shear, the combination of rotary knife carriers, having a plurality of knives spaced therein, means providing knife selection in the knife carriers, when setting up the shear, together with means for changing from one set of knives to another set of knives, in said knife carriers, while the shear is running, means for throwing said knife carriers out of shearing position, at a predetermined position of said knife carriers, means including a swinging finder, together with means providing a predetermined arrangement of controlling lights, for finding the full width of the material to be sheared, cooperating with a photo-electric relay, to throw the said knife carriers into shearing position with the nearest conveniently located pair of knives.

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